SAN JOAQUIN VALLEY AGRICULTURAL WATER COMMITTEE

WATER RESOURCES MANAGEMENT IN THE SOUTHERN SAN JOAQUIN VALLEY CALIFORNIA

A STUDY OF THE PHYSICAL AND INSTITUTIONAL MANAGEMENT PRACTICES FOR SURFACE AND GROUND WATER UTILIZATION

Bookman-Edmonston Engineering, Inc.
Glendale • Bakersfield • Sacramento
Phoenix • Washington, D.C.

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ACKNOWLEDGMENTS

During the course of this investigation and in the preparation of the report, a vast amount of information and data were provided by numerous organizations. The contribution of the following entities and the time and effort spent by their officials, staffs and advisors is gratefully acknowledged:

Alpaugh I. D.
Alta I. D.
Arvin-Edison W. S. D.
City of Bakersfield
Broadview W. D.
Buena Vista W. S. D.
State of California,
Department of Water Resources
Cawelo W. D.
Central California I. D.
Chowchilla W. D.
Columbia Canal Co.
Consolidated I. D.
Corcoran I. D.
Crescent Canal Co.
Delano-Earlimart I. D.
Ducor I. D.
Eagle Field W. D.
Empire Westside I. D.
Exeter I. D.
Farmers W. D.
Firebaugh Canal Co.
City of Fresno
Fresno I. D.
Fresno Metropolitan F. C. D.
Garfield W. D.
Gravelly Ford W. D.
Henry Miller W. D.
Hills Valley I. D.
Hope W. D.
International W. D.
Ivanhoe I. D.
James I. D.
John Heinlen Mutual Water Co.
Kaweah Delta W. C. D.
Kern County Water Agency
Kern County Water Agency —I.D. No. 4
Kern Delta W. D.
Kern-Tulare W. D.
Kings County W. D.
Kings River C. D.
Kings River W. D.
Laguna I. D.
Lakeside Irrigation W. D.
Lemoore Canal & Irrigation Co.
Lewis Creek W. D.
Liberty Mill Race Co.
Liberty W. D.
Lindmore I. D.
Lindsay-Strathmore I. D.
Lower Tule River I. D.
Madera I. D.
Mercy Springs W. D.
North Kern W. S. D.
Olcese W. D.
Orange Cove I. D.
Panoche W. D.
Pioneer Water Co.
Pixley I. D.
Porterville I. D.
Rag Gulch W. D.
Raisin City W. D.
Riverdale I. D.
Rosedale-Rio Bravo W. S. D.
Salyer W. D.
San Luis W. D.
Saucelito I. D.
Semitropic W. S. D.
Shafter-Wasco I. D.
Southern San Joaquin Municipal Utility District
Stinson Canal Co.
Stinson W. D.
Stone Corral I. D.
Stratford I. D.
Tea Pot Dome W. D.
Terra Bella I. D.
Traction W. D.
Tranquillity I. D.
Tulare I. D.
Tulare Lake Basin W. S. D.
United States Department of the Army,
Corps of Engineers
United States Department of the Interior,
Bureau of Reclamation
Vandalia I. D.
West Kern County W. D.
Westlands W. D.
Wheeler Ridge-Maricopa W. S. D.

Special mention is made of, and appreciation given to, the following persons who generously contributed their time and expertise in reviewing the preliminary version of this report:

W. A. Alexander, Consulting Engineer, Porterville, California

William Balch, Executive Vice President, Tenneco West, Inc.

Cecil Carey, Manager, San Luis Water District

Brent L. Graham, Manager, Tulare Lake Basin Water Storage District

Melvin Jans, Senior Vice President, Tenneco West, Inc.

William R. Johnston, Assistant Manager, Westlands Water District

Howard Keck, Assistant Manager-Engineer, Fresno Irrigation District

Robert E. Leake, Jr., Watermaster, Kings River Water Association

Wm. H. McGlasson, Consulting Engineer of McGlasson & Associates, Consulting Engineers, Fresno, California

Stanley T. Nelson, Engineer-Manager, Semitropic Water Storage District

James R. Provost, Consulting Engineer of Provost & Pritchard, Fresno, California

George E. Ribble, Assistant Engineer-Manager, Kern County Water Agency

Roger W. Robb, Engineer-Manager, Lower Tule River Irrigation District

Arnold S. Rummelsburg, Engineer-Manager, Wheeler Ridge-Maricopa Water Storage District

H. K. Russell, Engineer-Manager, Buena Vista Water Storage District

R. L. Schafer, Consulting Engineer of R. L. Schafer & Associates, Inc., Civil & Consulting Engineers, Visalia and Porterville, California

James F. Sorensen, Consulting Engineer, Visalia, California

Robert L. Stanfield, General Manager-Chief Engineer, Madera Irrigation District

Howard Stoddard, Consulting Engineer of Stoddard & Associates, Civil Engineers, Los Banos, California

Joseph B. Summers, Civil Engineer, Hanford, California

C. E. Trotter, Engineer-Manager, Arvin-Edison Water Storage District

C. H. Williams, Engineer-Manager, North Kern Water Storage District

Photo Courtesy Kern County Water Agency.

Management and conjunctive use of water supplies from Central Valley Project, State Water Project and Kern River are made possible by water transfers in interconnecting water conveyance facilities westerly of Bakersfield.

CHAPTER I

INTRODUCTION

This report has been prepared on behalf of the San Joaquin Valley Agricultural Water Committee, representing the five-county area of Madera, Fresno, Kings, Tulare and Kern, to identify the magnitude of present and future needs for supplemental water, to evaluate the impact of failure to provide adequate supplies of supplemental water to the area in a timely manner, and to determine the status of the physical and institutional management practices for surface and ground water utilization.

The report is intended to provide a factual basis for use by the Legislature, State and Federal administrations and general public in furtherance of sound programs of water resource development.

Certain significant and far reaching recommendations, particularly with respect to ground water rights, have been made by the Governor's Commission to Review California Water Rights Law. The Commission has proposed legislation which, if adopted by the Legislature, would drastically alter present concepts of ground water law and would repudiate existing State policy with respect to water resource development. Some of the impacts of the Commission's recommendations on the southern San Joaquin Valley are also addressed in this report.

Area of Investigation

The area reported on herein, termed the ''southern San Joaquin Valley,'' encompasses the portion of California bounded by the Tehachapi Mountains on the south, the Madera-Merced county line on the north, the Sierra Nevada on the east and the Diablo and Temblor ranges on the west. Specifically, the area reported on is that portion of the Valley floor in the counties of Madera, Fresno, Kings, Tulare and Kern. Certain of the organized areas studied extend northerly into Merced and Stanislaus Counties. The major portion of the study area is the Tulare Basin Hydrologic Area as designated by the State Department of Water Resources (DWR) or Basin 5-D as designated by the State Water Resources Control Board (SWRCB). The remainder is in the southern portion of the San Joaquin Hydrologic Area or Basin 5-C. The location of the area of investigation is shown on Figure 1.

The area contains about 6,100 square miles and has approximately 3.8 million acres developed to irrigated agriculture and urban and suburban uses. The population of the area is in excess of one million, with the cities of Madera, Fresno, Hanford, Tulare, Visalia, Delano and Bakersfield and their environs constituting the principal urbanized areas.

Increasing demands for water in the southern portion of the San Joaquin Valley have exceeded local water supplies and water imported to the Valley through the Federal Central Valley Project (CVP) and State Water Project (SWP). The imbalance between supply and demand has been met by overdraft on ground water.

At present about 12 million acre-feet of water are utilized annually for agricultural and urban and suburban purposes which comprises about one-third of the water use in the State.

The Problem

Ever-increasing demands for food and fiber in the nation and throughout the world have, since before the turn of the century, provided the economic motivation for continued development of the rich agricultural lands of the San Joaquin Valley.

From time to time the historical rate of development has outstripped the institutional ability of local, state and federal agencies to provide needed supplemental water to keep pace with this development, which is now essential to the economic health of the State and Nation, and temporary reliance has been placed on mining of ground water reserves to sustain the development.

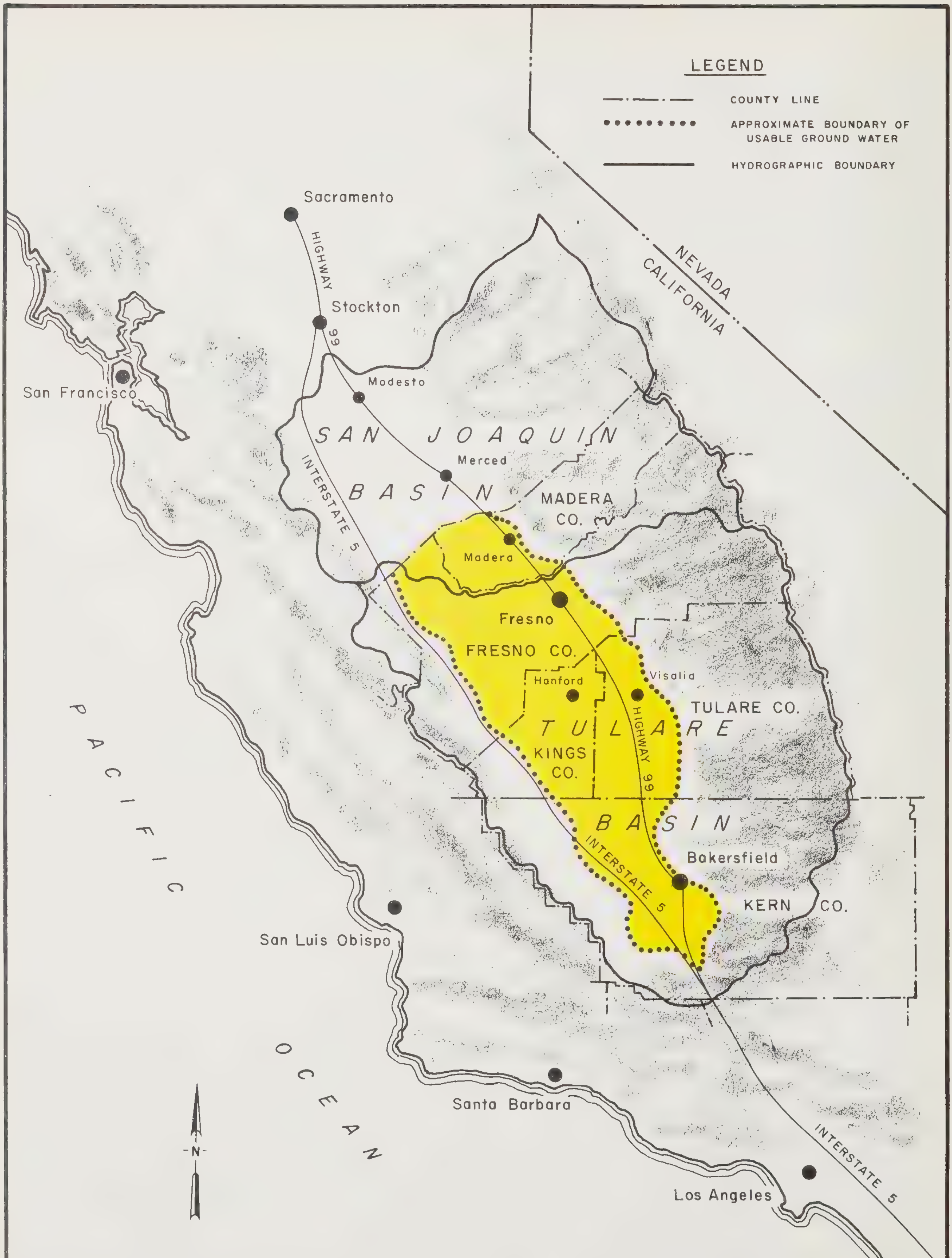
The CVP for a time established a balance between water supply and use on the east side of the Valley with construction of the Madera and Friant-Kern canals, but continued development dictated planning of the proposed East Side Project. Although the original concept of this project is no longer being pursued, the Mid-Valley Canal has now been proposed as a substitute, in part, and has been looked to as a means of relieving a portion of the current overdraft on the east side.

Water supplies imported through the Delta-Mendota and San Luis canals have also fallen short of meeting the supplemental needs of their service areas because of poorer quality ground water than was expected.

The SWP commenced delivering water to the southern San Joaquin Valley in 1968. The Project was planned to provide sufficient water to correct the existing overdraft in Kern County and portions of Kings and Tulare counties, and to provide for the needs of projected development until year 1990. This Project has not been completed as planned. The Peripheral Canal has not been built nor have the additional water conservation facilities in the North Coast been constructed as originally planned.

Actions of the State Water Resources Control Board through its water rights decisions and water qual-

FIGURE 1



THE SOUTHERN SAN JOAQUIN VALLEY

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JANUARY 1979

ity control plans, have significantly decreased the quantities of water available to the San Joaquin Valley. Further, operational policies of the California Department of Water Resources and interpretation of contract provisions relative to the delivery of surplus water, are resulting in actual delivered supplies substantially less than planned.

As a consequence of the foregoing, a ground water overdraft persists in the SWP service area in the San Joaquin Valley.

Manifestations of overdraft in the Valley are a continuing lowering of ground water levels accompanied by an increase in use of electric energy for pumping and attendant increased costs. Land subsidence continues in some areas. There are certain localized problems of water quality. The most severe problems of ground water quality are in western Fresno and Merced counties not associated with overdraft, but where additional surface water is needed to replace ground water of unusable quality.

Failure to complete the programs of water importation has most severely impacted the SWP service area, where hundreds of millions of dollars have been expended in the construction of facilities to conjunctively utilize the imported surface water with ground water. Payments on bonds and to lending agencies will continue even though the surface water supply will be less than planned. Use, where possible, will be then made of the underlying ground water, resulting in a continuation of overdraft, a declining ground water table and increased costs. Landowners must maintain their wells to provide a dual water supply which also adds to their costs.

Present State Policy on Water Resource Development

Present policy of the State of California on water resource development is set forth in Bulletin No. 3 of the DWR entitled "The California Water Plan". This plan was adopted by the Legislature in 1959 and codified as Sections 10004 et seq. of the California Water Code.

This policy provides for the orderly development of the water resources of the State as the demands therefor arise, through construction of dams, reservoirs, and conveyance facilities to regulate, conserve and transport water from areas of surplus to areas of need. Bulletin No. 3 demonstrates that there is an adequate supply of water in California, including the rights of entities in the State to the waters of the Colorado River, to supply the needs of the ultimate development of the State.

Outlined in Bulletin No. 3 are projects to provide for these ultimate water needs, with each project to be subjected to the tests of financial feasibility and economic justification prior to initiation.

The plan envisions conjunctive operation of surface and ground water resources to maximize efficiency of water use and to minimize costs.

Existing State water policy is thus a positive one which encourages economic development and, recognizing the dependency of such development on an adequate water supply, establishes procedures for making it available when needed.

Ground Water Rights Law

Ground water rights law in California is based on the general concept of correlative rights of overlying owners to ground water. In the correlative rights doctrine set forth in *Katz v. Walkinshaw*, the Court decided that where the ground water supply is inadequate to meet all overlying demands, it is necessary to have a doctrine which protects existing investment and provides certainty for future capital investments. The 1928 constitutional amendment formalized the doctrine of correlative rights and added the criterion of reasonable beneficial use.

Most of the ground water law has evolved from court cases, particularly in *Pasadena v. Alhambra*. In this first adjudication by the courts of a ground water basin, the doctrine of "mutual prescription" was developed which recognized that in an overdrafted ground water basin, all pumping was adverse to other pumping. On this basis, pumpers were reduced to a pro rata share of the calculated safe yield of the basin. However, the Pasadena case did not consider overlying water producers, such as agricultural users, since the area had become essentially urbanized. In this situation, as in subsequent adjudications using this same doctrine, there was an alternative available supply and no reduction in water use occurred.

In 1975, in *Los Angeles v. San Fernando*, the Court clarified the doctrine of correlative rights to recognize equitable arrangements other than pro rata sharing of the safe yield. In the San Fernando Case, the Court found that an overlying owner in an overdrafted basin may retain his original overlying rights or prescriptive rights obtained by continuing to pump. The judgment in this case is not clear as to whether overlying rights which have never been exercised can be lost in prescription, but it is believed that what the Court was pointing out was that such rights may be protected by an overlying owner if, prior to the prescriptive period, a declaratory judgment is obtained. An important finding of the Court in the San Fernando Case was that public water supply rights such as those held by cities are excluded from prescription. The judgment in the case also recognized the right to store water in the ground water basin for later extraction and use.

Reference is made to the comprehensive discussion of ground water rights law set forth in the report by Anne J. Schneider to the Governor's Commission to Review California Water Rights Law entitled "Groundwater Rights in California" dated July 1977. The author has made a valuable contribution to this important but complex subject.

Proposals for Modification of Ground Water Rights Law

In recent years a number of proposals to modify ground water rights law by legislative action have been discussed throughout the State. The most recent and far reaching of these proposals, with respect to modifying existing law, are contained in the report of the Governor's Commission to Review California Water Rights Law.

Proposed is a statutory procedure involving DWR, SWRCB, and local agencies whereby areas of ground water overdraft in the State would be identified, ground water management agencies created or existing agencies appointed to carry out the management function, and management plans developed for review by SWRCB. In essence, the policy of the proposal is to eliminate ground water overdrafts by a reduction in extractions to estimated safe yield levels with subsequent continuing control of extractions.

Although local control is articulated as being desirable and an objective of the legislation, control of ground water use would effectively rest in the State Water Resources Control Board.

Scope of the Investigation and Report

The investigation for this report included evaluations of the present and future utilization of the surface and ground water resources of the five counties in the southern San Joaquin Valley, the economic impact of agriculture, the potential for additional water supplies and ground water management activities now being pursued.

Data from existing Federal, State and local agency reports were used to the extent possible, as well as unpublished data from many operating agencies. Questionnaires were addressed to, and interviews were conducted with, representatives of over 80 water agencies in the study area. From these interviews, details of the present ground water management programs were determined. Knowledge and experience of the firm of Bookman-Edmonston Engineering, Inc. in the development of ground water management programs in the San Joaquin Valley, southern California and Central Coastal areas was also used in the preparation of this report.

CHAPTER II

SUMMARY OF CONCLUSIONS AND FINDINGS

Presented herein is a summary of the conclusions and findings of this investigation and report on water resource management in Madera, Fresno, Kings, Tulare and Kern counties in the southern San Joaquin Valley.

Principal Conclusions and Findings

(1) There is a present annual ground water overdraft in southern San Joaquin Valley of 1.4 million acre-feet which, with completion of the State Water Project (SWP) and full delivery of water therefrom, would be reduced to about 900,000 acre-feet.

(2) About 490,000 acres, or 12.5 per cent of the total area of the Valley overlying usable ground water, constitute irrigable undeveloped lands. Under favorable economic conditions, about 220,000 acres of this developable land may reasonably be expected to be irrigated from ground water by year 2000. This development, together with additional urban demands and requirements for drainage disposal, would increase the overdraft from 900,000 acre-feet to 1.7 million acre-feet per year.

(3) Completion of the SWP is essential to the maintenance of the economy of the southern San Joaquin Valley. With delay in such completion, the substantial investment in facilities to carry out conjunctive-use operations must be repaid, without receipt of the amounts of water contemplated, which would impose a severe financial hardship on the affected areas. The adverse financial impact would be even greater in the portion of the SWP service area that does not have access to ground water.

(4) The southern San Joaquin Valley now has the physical and institutional tools necessary to integrate required additional amounts of supplemental surface water into present conjunctive-use operations, as evidenced by the existence of 63 entities now operating ground water management programs, covering nearly 90 percent of the total area overlying usable ground water in the Valley.

(5) The future of the southern San Joaquin Valley is largely dependent on actions of State and Federal legislative and administrative institutions. There are limited options available and actions (or the inaction) of these institutions will result in creation of one of the following future scenarios in the Valley:

(a) Elimination from production of about 600,000 acres of presently irrigated land and a loss to the economy of the State of $1.6 billion annually, which would occur if a reduction and control of ground water extractions to an estimated safe yield were to be mandated as a result of enactment and implementation of legislation proposed by the Governor's Commission to Review California Water Rights Law. In this regard, no ground water basin in California has been adjudicated and no restrictions on the pumpage of ground water have been instituted, without the availability of an adequate supply of supplemental water to maintain the level of total water use existing prior to the adjudication and imposition of the restrictions.

(b) A continuation of unmitigated overdraft, which would cause a gradual elimination of land from production and economic loss as pumping costs and energy use continue to increase with receding ground water levels. This would occur without positive actions to develop additional supplemental water.

(c) A balanced condition of water supply and use, accompanied by continued productivity of the present irrigated area and a nominal enlargement of this area, consistent with economic factors. These conditions would prevail with furtherance of water resource development programs and delivery of required amounts of supplemental water to the Valley, as envisioned in The California Water Plan — the basis of the present water policy of the State of California, as set forth in the Water Code.

Additional Conclusions and Findings

Additional conclusions and findings are presented following:

Land and Water Use

(1) The irrigated area in the southern San Joaquin Valley is now 3.8 million acres, utilizing about 12 million acre-feet of water annually and having an annual consumptive water requirement of about 8.7 million acre-feet.

(2) On the basis of land use and economic studies of the California Department of Water Resources (DWR), it is indicated that, by year 2000, the irrigated area could increase to 4.1 million acres with an annual consumptive requirement of 9.4 million acre-feet.

(3) There are presently 425,000 acre-feet of water delivered annually for urban and related uses, which amount may reasonably be expected to increase to about 600,000 acre-feet by year 2000.

(4) There are about 3.9 million acres of land in the southern San Joaquin Valley overlying usable ground water, of which about 3.3 million acres are now receiving water service. For the most part, the better lands have been developed. The area of undeveloped irrigable land with development potential, overlying usable ground water, is estimated to be 490,000 acres. Undeveloped irrigable lands will be brought under irrigation only with favorable economic conditions and continuation of the stimulus provided by urbanization of farm lands in California. It is reasonable to expect about 220,000 acres of these lands to be developed and irrigated by year 2000.

(5) Agricultural drainage problems will continue to increase. Removal of brackish drainage water in excess of 200,000 acre-feet per year will be required by year 2000 according to Federal and State studies. If certain programs of surface and ground water integration, now under study, cannot be implemented because of unacceptable ground water quality, then the required amount of disposal will increase.

Agricultural Economy

(1) Agricultural production in California has a current direct value of about $10.1 billion and supports a total business activity of about $30 billion.

(2) The five southern San Joaquin Valley counties, producing a wide variety of crops, including deciduous fruits, citrus, nuts, grapes, cotton, field and vegetable crops, are leaders in California in value of agricultural production. Three of these counties, Fresno, Kern and Tulare, are among the top five agricultural counties in the United States.

(3) The 1977 direct value of crops and livestock produced in the five-county area was over $3.2 billion. The average direct value of production was $885 per irrigated acre.

Water Supply and Need for Supplemental Water

(1) Mean annual runoff of surface streams in the southern San Joaquin Valley study area is 5.2 million acre-feet, of which about 5 million acre-feet is utilized directly or recharged to the ground water basin.

(2) Present imported water supplies from the Sacramento-San Joaquin Delta are about 2 million acre-feet per year from the Federal Central Valley Project (CVP) and about 700,000 acre-feet per year from the SWP.

(3) The difference between the available supply and the sum of consumptive use, irrecoverable losses and drainage water disposal, is the supplemental water requirement, now met by ground water overdraft. The present annual overdraft is about 1.4 million acre-feet and could increase to about 1.7 million acre-feet by year 2000, with allowances for urban growth and drainage water disposal. The projected overdraft by year 2000 would be increased to the extent that the SWP would be unable to deliver its full contractual supply.

(4) In the CVP service area on the west side of the Valley, some additional supplemental water is required to supplant use of ground water of unacceptable quality. In portions of this area, additional water will be required for full utilization of developed lands to the extent ground water of inferior quality cannot be integrated into surface supplies, as originally envisioned.

(5) Opportunities to "stretch" existing water supplies, and thereby reduce supplemental water requirements are limited because of present intensive reuse practices and physical and economic factors. The major portion of the area is in the Tulare Basin, which now has an overall water-use efficiency of 96 percent.

(6) On-farm irrigation efficiencies could be increased to a limited extent under certain physical and economic conditions. Such increases are limited by the greater cost of more sophisticated irrigation facilities and the requirements for leaching of salts through the soil profile. Any increase in on-farm irrigation efficiency on lands overlying unconfined ground water, which may reduce the costs to the farmer, does not increase overall basin water-use efficiency.

Ground Water Management

(1) Ground water management and the conjunctive use of surface and ground water have been carried on in the southern San Joaquin Valley for a period of nearly 50 years.

(2) There are 63 separate entities now engaged in ground water management in the southern San Joaquin Valley, including county agencies, public water districts and private organizations. Contained

within these entities is a total area of 3,391,000 acres or nearly 90 percent of the total area overlying usable ground water in the Valley, of which 3,003,000 acres comprise presently irrigated land and 313,000 acres, undeveloped irrigable land. Only 177,000 acres of presently undeveloped irrigable land, or about four percent of the total area overlying usable ground water, are not now included within a management institution.

(3) The vast array of conjunctive-use programs now in existence in the southern San Joaquin Valley, utilizing local and imported surface water with ground water, have been successfully implemented voluntarily, through programs of economic inducement and without mandatory control of ground water extractions.

(4) Financial programs, which have been established by Valley management entities, have been successful in marketing over 3 million acre-feet of surface water from the CVP and SWP, which has been used in lieu of ground water as part of the conjunctive-use operations. For the most part, these entities use a combination of water charges and taxes or assessments to achieve financial equity between surface and ground water users.

(5) Nearly $500 million has been invested by local management agencies in construction of facilities required to carry out conjunctive-use operations. Annual expenditures of these agencies exceed $70 million.

(6) Ground water management programs in the Valley are complex, requiring numerous and differing recharge techniques and use of exchanges and other cooperative measures involving both public and private entities.

(7) Effective ground water management has been achieved in several basins without control or mandatory reduction of ground water extractions, which basins include Orange County Ground Water Basin and Main San Gabriel River Basin in southern California, and the Santa Clara Valley in northern California.

(8) The existence of overdraft in the southern San Joaquin Valley does not indicate an ''unmanaged'' situation, but only the absence of an adequate supply of supplemental water to integrate into the conjunctive-use operations.

(9) Historically, extensive areas of the State have developed substantial economic bases through temporary mining of ground water resources, which then provided these areas with the financial resources to secure an imported water supply. Areas which have relied on ground water overdraft during some period in their development history, in addition to the southern San Joaquin Valley, include southern California and the San Francisco Bay area.

(10) The history of the San Joaquin Valley shows that, prior to the advent of supplemental water supplies, public agencies were formed in unorganized overdrafted areas to provide the institutional mechanisms to contract for supplemental water and to integrate it with ground water.

(11) Further flexibility in surface and ground water management could be achieved through additional water exchanges which would be possible with construction of the Mid-Valley Canal.

Consequences of Overdraft

(1) Unmitigated overdraft of the southern San Joaquin Valley ground water basin will result in a continued lowering of ground water levels. An estimated 150 million acre-feet of good quality ground water stored in the upper 500 feet of the alluvial deposits, as compared to the present estimated overdraft of 1.4 million acre-feet per year, assures a long-term supply, but at an ever-increasing cost.

(2) With continued overdraft, there would be additional surface land subsidence in portions of the basin. However, the ground water basin would not be irreparably damaged through loss of usable storage capacity, as has been substantiated by recent findings of the U. S. Geological Survey. Compaction would occur in clay lenses, but usable ground water storage capacity of the basin, which has and will continue to be utilized in the conjunctive-use operations for cyclic regulation, would not be lost by compaction of water-bearing deposits.

(3) There would be significant economic consequences of continued overdraft in the Valley. The use of electric energy for pumping would be substantially increased. The attendant increased water costs, under conditions of prolonged overdraft, would eventually cause a substantial amount of land to be removed from production with a corresponding loss to the economy. This would occur gradually, with lands having lower value crops and the greatest pumping lifts being the first to be retired from production. Costs would also be incurred to remedy the effects of land subsidence.

(4) Economic effects of continued overdraft would be particularly severe in the SWP service area, for the most part in Kern County. With completion of the SWP and without delivery of full contractual

entitlements to water, overdraft would persist. Expensive surface distribution systems essential to conjunctive-use operations, would have to be repaid by taxes or assessments on a reduced service area and landowners would incur the expense of maintenance of wells for continuity of delivery of irrigation water from a decreasing ground water supply.

(5) Little direct evidence of continuing ground water quality problems attributable to overdraft is found. Ground water of unusable quality does underlie a substantial area of western Fresno County, but this is not a result of overdraft. Localized problems of ground water quality do exist elsewhere in the Valley.

Potential Water Sources

(1) There are undeveloped water resources in the Sacramento Valley and the North Coastal area which could be conserved and conveyed to the southern San Joaquin Valley to eliminate the overdraft.

(2) The most urgently needed facility is the Peripheral Canal, which was authorized for State construction under the Burns-Porter Act, and no additional legislation is required to implement its construction.

(3) The Peripheral Canal would increase the present combined yield of the SWP and CVP by about 1.2 million acre-feet per year. As much as 600,000 acre-feet of this supply would accrue to the SWP, representing a significant portion of the water supply which the DWR is contractually committed to deliver to the project service area.

(4) New Melones Reservoir would provide additional yield in the Delta of about 220,000 acre-feet per year for export, until that yield is put to use in the service area adjacent to the project.

(5) In the Sacramento Valley, construction of Auburn Dam, on the American River, offers the major near-future potential for additional surface water development and could provide an additional water supply of 320,000 acre-feet annually. Cottonwood Creek Project could develop at least 170,000 acre-feet of additional water annually. Further studies are needed to evaluate the feasibility of enlarging Shasta Reservoir on the Sacramento River. This enlargement could provide an additional water supply of one million acre-feet per year or more.

(6) Potential storage developments on the Eel River, in the North Coast area, as contemplated in the Burns-Porter Act, could add over one million acre-feet to the water supply of the Sacramento-San Joaquin Delta and also provide local instream flow benefits.

(7) New conveyance facilities will be required to deliver required additional water supplies to the east side of the San Joaquin Valley. The Mid-Valley Canal is the logical facility to provide this needed conveyance capacity.

(8) There are many years when water is physically available in the Delta for diversion in excess of prior commitments, which could be delivered through existing facilities of the SWP and CVP for direct irrigation service or ground water recharge. The most effective means of increasing the available supply of ground water would be to deliver this excess water, and "surplus water" under the SWP water service contracts, for use in lieu of ground water.

(9) Additional imported supplies required to alleviate ground water overdraft will be limited because of policies of the State Administration and the Secretary of the Interior and decisions of the State Water Resources Control Board. Decisions concerning the Delta and policies such as that regarding the filling and operation of New Melones Reservoir, have a significant impact on the availability of future water supplies.

CHAPTER III

LAND USE AND WATER REQUIREMENTS

Future water requirements are determined by a process that first considers population and agricultural production and, secondly, unit water use values. Urban and agricultural water requirements essentially constitute the total consumptive water demand in the San Joaquin Valley, with irrigated agriculture accounting for approximately 96 percent of the total use. Statewide, water use by irrigated agriculture amounts to about 85 percent of the total.

Population

California's population has increased every year since it gained statehood, and its rate of growth has consistently surpassed that of the nation. The present growth rate is much less than during the 1940's and 1950's, principally because of decreased in-migration.

Forecasts of future population are based on projected fertility rates and rates of net in-migration. The State Department of Finance prepares alternative projections of population for the State and individual counties utilizing factors developed by the U. S. Bureau of Census. The Bureau of Census designates "population series" which are most likely to occur as "C", "D", "E", with corresponding fertility rates (defined as the number of children under five years of age per 1,000 females in the childbearing age group) of 2.8, 2.5, and 2.1, respectively. Net in-migration rates of 0 to 150,000 per year are considered practical possibilities. For purposes of evaluating future urban water requirements of the study area, a population projection based on Series "E" with a fertility rate of 2.1 and 150,000 annual net in-migration was utilized. The 1978 population for California was 22.3 million and, utilizing the foregoing factors, a population for year 2000 was derived to be 29.3 million. The present population of the five counties in the southern San Joaquin Valley, as determined by the California Department of Finance, and the projected year 2000 population for each county, based on a State population of 29.3 million, are presented in Table 1.

TABLE 1
PRESENT AND PROJECTED POPULATION IN THE FIVE SOUTHERN SAN JOAQUIN VALLEY COUNTIES
[E-150 Projection]

	Year	
	1978	2000
Madera	53,000	78,000
Fresno	478,000	696,000
Kings	71,000	95,000
Tulare	225,000	339,000
Kern (S.J.V. portion)	322,000	414,000
Total	1,149,000	1,622,000

Agricultural Land Use

The physical factors of soils, water, climate and topography have played the major role in the expansion of irrigated agriculture in the San Joaquin Valley. For the area as a whole, none of these factors has been a constraint in development. The economic aspects of agriculture are discussed in a subsequent section of this report. The rate of land development and expansion of agriculture in California and the San Joaquin Valley reflect the free market system, which includes motivating factors of national and State population growth, per capita consumption, changes in crop yields, foreign trade and California's share of the national production.

An additional factor affecting agricultural development in the San Joaquin Valley is the relocation of agriculture from other areas of California because of urbanization. In recent years, such urbanization has been occurring on irrigated lands at the rate of 20,000 acres annually. Much of this displaced agricultural activity has been relocated to the San Joaquin Valley.

Up to this time, water has not been a limiting factor in agricultural expansion in the Valley, because local surface water sources have been developed, ground water has been available and imported water has been developed and delivered under Federal and State programs. Ground water quality degradation has occurred in some areas because of migration of saline connate water into the ground water extraction zones and because of percolation of drainage water carrying salt from the soil profile. Economic factors of electrical power and well development costs also may impede the continued rate of development.

Another constraint on future land development in the Valley can be the economic cost of production and lower crop yields on the poorer soils that constitute most of the undeveloped lands on the floor of the Valley. Although these lands may overlie usable ground water, the economic realities of the limiting factors of poor soils, drainage problems and high water costs, may reduce the future growth rate. Irrigable but undeveloped land is available around the periphery of the Valley with fewer soils and drainage problems, but much of this land does not overlie usable ground water. Unless an imported supply of water is brought in specifically for these areas, they will not develop. Thus, there is a finite limit on the additional irrigated land development and increased overdraft that will occur in the southern San Joaquin Valley under present conditions.

The irrigated areas in the southern San Joaquin Valley in 1977, as determined from County Agricultural Commissioners' reports, are shown in Table 2.

TABLE 2
PRESENT IRRIGATED LAND IN THE SOUTHERN SAN JOAQUIN VALLEY
[1,000 acres]

County	1977
Madera	299
Fresno	1,253
Kings	605
Tulare	708
Kern	930
Total	3,795

Present cropping patterns and yields are discussed in a subsequent section.

Potential for New Irrigation

The potential for expansion of irrigation in the San Joaquin Valley is limited primarily by availability of suitable land, by the availability of ground water and by costs of development and operation. With modern land development machinery, soil amendments, fertilizers, and sprinkler and drip irrigation equipment, a wide range of soils could be made productive. The costs, however, may limit development. Soil characteristics and cost of water can be used to evaluate a realistic potential for new irrigation.

The likelihood of new land being irrigated will depend on the economic availability of ground water, except in limited areas which may yet develop with surface water under current contracts for water from SWP. The initial step in determining irrigation potenial was, therefore, the determination of the approximate areal limits of usable ground water. This was done on the basis of available reports and knowledge of present pumping and well drilling success. Reports of the U. S. Geological Survey (USGS), DWR and local districts were used. The outside limits of developable ground water in the southern San Joaquin Valley are illustrated on Figure 1, which was presented in Chapter 1.

The DWR makes periodic surveys of the use of land throughout California to provide information for water use studies. The five San Joaquin Valley counties were surveyed at different times between 1968 and 1977 and the average age of the data is about 5 years. These surveys included all types of land use including both developed and undeveloped. Most of the undeveloped land was categorized as native vegetation and, in the Valley areas, is considered to be subject to cultivation. Each quadrangle upon which the land use categories were delineated was identified as being either within or without, or partially within, the area of developable ground water. The tabulated areas of native vegetation for the quadrangles within the area of developable ground water, and pro rata areas of native vegetation for quadrangles partially within the area of developable ground water, were accumulated. On this basis, the remaining developable land overlying ground water was determined to be 575,000 acres. With present-day equipment and soil amendments, practically all the Valley land could be developed for irrigation if the economics justify the undertaking.

Economics of development, as affected by the characteristics of the land, was the next main factor in estimating the irrigable potential. For this determination, use was made of the 1958 DWR classification survey of the physical characteristics of land in the San Joaquin Valley. Lands were classified in three categories of slope and in categories of soil conditions such as salinity, alkalinity, texture, drainage and high water table, effective root zone and unevenness or microrelief. The areas of lands in each of the quadrangle maps covering the Valley area were tabulated by DWR according to the aforementioned categories.

For the purposes of this study, the DWR tabulated data were used to group the lands into three categories according to the severity of development problems. The salinity and alkalinity of the soil was the dominant factor. The following descriptions from the DWR data were the primary basis for the the three groups:

Group I Excess of soluble salts or exchangeable sodium present in slight amounts.

Group II Excess of soluble salts or exchangeable sodium present in moderate amounts.

Group III Excess of soluble salts or exchangeable sodium present in large amounts.

Where lands were indicated to have other characteristics such as heavy soil texture, shallow root depth and high water table, which would increase the difficulty of development, such lands were moved to a lower group than indicated by the salinity factors. The areas of land in each of these three groups were tabulated for each quadrangle area and the previously determined areas of undeveloped lands overlying developable ground water were segregated into these groups by the procedure described following.

As the better lands have already been developed, it was assumed that the native vegetation is generally on the poorest lands in Group III. Therefore, for each quadrangle all lands in native vegetation were assumed to be in Group III unless the area in native vegetation exceeded the area in Group III, in which case the balance of the native vegetation was assumed to be in Group II. By the same process, some native vegetation was also assigned to Group I.

The final step in determining the potential for new irrigation gave consideration to the depth to ground water. An average pumping depth was determined for each quadrangle area. On the basis of crop payment capacities determined in other studies and information on farming operations from individuals from the Valley, it was concluded that it would generally be uneconomical to

Photo Courtesy U.S. Bureau of Reclamation.

Siphon diversions into furrows in a young cantaloupe field in the western San Joaquin Valley provide uniformity of water application.

initiate irrigation on land in Group III if the pumping depth exceeded 250 feet, and in Group II if the depth exceeded 350 feet. Therefore, lands in Groups II and III were considered not subject to development if located on quadrangles where these depth criteria were estimated to be exceeded. A criterion of 450 feet of pumping depth was assumed for lands in Group I, but no lands in Group I were found where ground water exceeded this pumping depth. As a result of application of these ground water depth criteria, the area of land considered to be potentially developable was reduced by some 53,000 acres or about 10 percent of the previously determined potential area of some 575,000 acres.

Adjustments were also made to account for about 24,000 acres in the Kern and Pixley Wildlife Refuge areas and the Mendota Wildlife Area, which it is assumed would not be developed for irrigation. Also, the new landowners within the Hacienda Water District are in the process of taking about 7,000 acres of irrigated land out of production in a water exchange program, and an additional 8,000 acres of native vegetation in that District are not expected to develop. These considerations further reduce the area of potential irrigation development by some 32,000 acres.

The foregoing analysis indicated that there are about 490,000 acres with development potential (575,000 minus 53,000 minus 32,000) of irrigable land overlying ground water in the five counties, as shown in Table 3. This acreage represents the probable ultimate limit of the additional area that would develop on ground water. The amount of such development by the year 2000 will depend on other statewide factors.

Studies made by the DWR for Bulletin 160-74 projected the future irrigated acreage in California on the basis of five growth regulating factors. These were national population, per capita consumption, net foreign trade, State share of United States production, and crop yield. Different combinations of these factors result in different alternative futures, and these alternatives were projected for each of the State's hydrologic areas. For this report, the San Joaquin and Tulare Basin hydrologic areas were considered in the midrange of the alternative futures for a share of the statewide growth. This growth would occur on the

undeveloped lands overlying usable ground water as economic conditions provide the incentive.

The average annual increase in the five counties would be about 13,000 acres per year, based on their share of the statewide growth in the demand for new irrigated area. On this basis, the additional irrigated area in the five counties by the year 2000 would be about 270,000 acres which, added to the presently irrigated area of 3,795,000 acres shown in Table 2, would result in a total irrigated area of about 4.1 million acres.

Approximately 50,000 acres of the 270,000 acres of additional irrigation would occur on lands that do not overlie ground water, but which are included in contracts for water supplies from the SWP. The remaining 220,000 acres, which overlie usable ground water, would be developed by utilizing the ground water source.

Urban Water Requirements

Water consumed for urban purposes includes domestic and industrial uses. The estimated rate of consumption is based on per capita values. Because of high temperatures and low humidity and rainfall in the Valley, the per capita rates of urban water use are higher than statewide averages. According to DWR Bulletin 160-74, urban water consumption in the southern San Joaquin Valley is about 0.37 acre-feet per capita per year, compared to statewide average use of 0.24 acre-feet per capita. Cooling water requirements for thermal electric power plants could become a significant quantity with inland siting. However, this is not expected to occur in the San Joaquin Valley during the next two decades, according to the siting schedules of the electric utilities. The present and projected urban water demands in the southern San Joaquin Valley are shown in Table 4.

TABLE 4

PRESENT AND PROJECTED URBAN APPLIED WATER DEMAND

[acre-feet]

County	1978	2,000
Madera	19,600	28,900
Fresno	176,000	257,500
Kings	26,300	35,200
Tulare	83,200	125,400
Kern	119,100	153,200
Totals	424,200	600,200

Studies made for the SWRCB Basin 5-D Water Quality Control Plan indicate that about 55 percent of the applied urban water demand is consumptively used. This amounts to about 234 thousand acre-feet per year under present conditions with the remainder available as waste water effluent for reuse. The consumptive requirement in year 2000 would be about 330 thousand acre-feet.

Agricultural Water Requirements

There are two aspects of agricultural water demands. These are the applied water requirements and consumptive use. Applied water requirements represent the amount of water that must be developed or delivered to the place of use. This includes the water transpired by the crop, evaporation from ground surface, water applied to leach salts from the root zones, deep percolation, and any surface runoff as tailwater or return flow. Consumptive use is the amount of available water transpired by the crop and evaporated from foliage and adjacent soil. The water available to the plant includes both the applied water and

TABLE 3

UNDEVELOPED IRRIGABLE LAND OVERLYING USABLE GROUND WATER

[1,000 acres]

County	Development Potential Group: Group I Least Difficult	Group II Difficult	Group III Most Difficult	Totals
Madera	18	22	31	71
Fresno	24	19	39	82
Kings	43	41	6	90
Tulare	43	63	19	125
Kern	32	77	13	122
Totals	160	222	108	490

soil moisture in the root zone from precipitation. The latter is the effective precipitation. The consumptive use component and other irrecoverable losses reduce the basin supply whereas the other components of the applied water become available for reuse within the basin and are counted in the total supply. Therefore, on-farm conservation practices, which do not reduce consumptive uses, do not necessarily increase the overall basin water supplies.

Net Water Use

Water required to satisfy consumptive use varies with the crop and climate and is expressed as a unit value in acre-feet per acre per year. The methods of determining consumptive use have been developed throughout California by experimental measurements. For crops grown in the San Joaquin Valley, an overall average value of 2.3 acre-feet per acre per year was calculated for the net water use of irrigated agriculture in DWR Bulletin No. 160-74. This value allows for consumptive use and other irrecoverable losses. For the 3.8 million acres of presently irrigated area in the five counties of the southern San Joaquin Valley, net agricultural water use is about 8.7 million acre-feet per year. For the year 2000, when 4.1 million acres may be irrigated, net water use could be about 9.4 million acre-feet.

Efficiency of Water Use

The efficiency with which water is used depends on the perspective from which it is viewed. Efficiency can refer to an individual farm, stream system or hydrologic basin.

Individual farm efficiency takes into account many factors, such as cultural practices, soil conditions and crop

Photo Courtesy State Department of Water Resources.

A center pivot sprinkler system for a cotton field requires a major investment in equipment.

patterns, and varies greatly depending on those factors. The ratio of consumptive use to applied water is a representation of that efficiency.

Cultural practices, such as irrigation methods and procedures, affect the amount of water which must be applied in excess of crop consumptive use. Such practices affect the amounts of water which percolate below the root zone or go to tailwater. The amount of applied water also includes percolation from conveyance ditches and canals. Where salts are to be leached, water in addition to the consumptive use may be significant.

Where water in excess of the consumptive use is applied and does not percolate, it may become tailwater at the lower part of the field. Here it may evaporate, be pumped through a reuse system for further irrigation or drain into natural water courses where it becomes available for further use. Water use efficiency may also be affected by economic considerations. Installation of facilities such as sprinklers or drippers, and the associated pumping equipment, which can reduce the applied water demand, may require significant capital investment. These have been found to be justified where soils, water costs, crop types, and other conditions warrant their installation.

Water conservation and farm reuse do not necessarily increase the water supply of the hydrologic basin because excess applied water may return to the supply and be reused. Water removed from the basin includes evapotranspiration, evaporation from ponded water, surface runoff and drainage to carry away salts.

Where tight clay lenses occur in the soil profile, a perched water table of brackish water may be created. While this water may be held in storage, it will eventually have to be removed as drainage to prevent accumulation of salt in the root zone. This perched water table may overlie usable ground water aquifers.

Studies of this problem have been made for many years by numerous agencies. Current studies are underway by the San Joaquin Valley Interagency Drainage Program (IDP) composed of the USBR, DWR and SWRCB. The IDP in its report on "Agricultural Drainage and Salt Management in the San Joaquin Valley," dated January 1976, estimated that about 232,000 acre-feet will be the year 2000 annual quantity of drainage water produced in the southern San Joaquin Valley which will not be practicably recyclable, and will have to be removed to prevent adverse salt balance.

At the present time, the only unusable agricultural waste water being removed from the basin is that which evaporates from the evaporation basins constructed by local agencies. This amounts to about 3,000 acre-feet per year. Some agricultural drainage is reused on grasslands and other wetlands for wildlife habitat. Where irrigation drainage and return flows are reduced through more efficient conveyance and on-farm systems, there may be a loss of phreatophytes and other vegetation for wildlife habitat. Nesting waterfowl, upland game, small mammals and other nongame animals may be adversely affected.

The hydrologic basin efficiency takes into account the availability of return flows and percolating water that are a part of the water supply and are available for reuse within the basin. The Tulare Basin Hydrologic Area has an efficiency of about 96 percent, as reported in DWR Bulletin 198, "Water Conservation in California", May 1976. The bulletin indicates that this efficiency is too high for the effective removal of salts.

CHAPTER IV

WATER RESOURCES

The water resources available for use in the southern San Joaquin Valley consist of runoff from the mountains and foothills and imported water diverted from the Sacramento-San Joaquin Delta. Percolation from stream channels and recharge basins and from applied irrigation water contribute to the ground water supply. This chapter presents a discussion of these sources of water supply and an analysis of water supply and disposal for the study area. A schematic diagram of water distribution and management is shown on Plate 1, "Principal Surface Water Supply Features".

Surface Water

The southern San Joaquin Valley is drained by the San Joaquin River and its tributaries, although Tulare Lake Basin has historically collected most of the runoff of the southerly streams. Although the latter is essentially a closed basin, historically, it has filled and spilled to the San Joaquin River and the ocean. This last occurred in 1862. Most of the runoff occurs from streams which drain rugged mountainous areas of the Sierra Nevada with elevations ranging to over 14,000 feet.

The stream system, for purposes of this report, is divided into major and minor streams. Major east-side streams listed from north to south include the Chowchilla, Fresno, San Joaquin, Kings, Kaweah, Tule and Kern rivers. Minor streams on the east side include Daulton, Cottonwood, Limekiln, Yokohl, Deer, Poso, Caliente and Tejon creeks and the White River. The west-side minor streams include Panoche, Cantua, Los Gatos and Avenal Gap creeks.

The Chowchilla River drains a secondary watershed of about 238 square miles above the Valley floor. About 68 percent of the watershed lies at an elevation of less than 2,500 feet. The River channel divides after reaching the Valley floor and water percolates to the ground water basin or is diverted for irrigation use. Only during high flow stages does it reach the San Joaquin River. The Chowchilla River is controlled by Buchanan Dam and Reservoir. The average annual runoff at Buchanan Dam is about 71,000 acre-feet.

The Fresno River has a drainage area of 270 square miles above the Valley floor with 62 percent of the watershed below elevation 2,500 feet. Runoff comes primarily from rainfall and averages about 100,000 acre-feet per year. Upon reaching the Valley floor, the streambed broadens to a wide sandy channel in which much of the runoff percolates to the ground water body. The Fresno River is controlled by Hidden Dam and Reservoir.

The drainage area of the main San Joaquin River rises from the Valley floor to elevations in excess of 10,000 feet in the Sierra Nevada. After entering the Valley floor, the River flows westerly to the center of the Valley where it turns northwest and traverses the remainder of the San Joaquin Valley to the Sacramento-San Joaquin Delta after being joined by other tributaries. The watershed is extremely rugged and has peaks greater than 13,000 feet. The San Joaquin River is controlled by Friant Dam and Reservoir (Millerton Lake) and by several upstream reservoirs constructed for power generation purposes. The drainage area encompasses 1,631 square miles above Friant Dam, of which area 75 percent is at an elevation of 5,000 feet or more. Runoff is characteristic of a snowmelt stream, that is, while most of the precipitation on the drainage area, in the form of snow, occurs during the months of December to April, a large part of the runoff from the melting snow occurs after April, continuing into July and even to August in some years. Runoff of the San Joaquin River averages about 1,762,000 acre-feet per year.

The Kings River drains an area of 1,694 square miles above Piedra. The watershed is extremely steep and rough with some of the highest elevations in the 48 contiguous states. About 71 percent of the drainage area is above 5,000 feet. Runoff from rainfall occurs very rapidly, as 22 percent of the watershed is at an elevation of 10,000 feet or more and consists of surfaces of granite made bare by glacial action. Runoff is mainly characteristic of a snowmelt watershed similar to that of the San Joaquin River. The Kings River has developed a large alluvial fan on the Valley floor. After reaching the Valley floor, the main channel rides the ridge of the alluvial fan and passes northwesterly through Fresno Slough to the San Joaquin River near Mendota. Outflow to the San Joaquin River occurs in about one of every four years and averages about 127,000 acre-feet per year. During high flows, discharge also occurs through the South Fork Channel of the Kings River southerly into Tulare Lake. The Kings River is controlled by Pine Flat Dam and Reservoir and by two upstream reservoirs constructed for power generation purposes. The average annual runoff of the Kings River at Piedra is about 1,659,000 acre-feet per year.

The Kaweah River drains an area of 561 square miles of the Sierra Nevada. The headwaters are at elevations of up to 12,600 feet, with 61 percent of the drainage area lying at elevations over 5,000 feet. Runoff is characteristic of a

snowmelt stream. Below the foothills the river divides into several distributaries which cross the alluvial fan and terminate in Tulare Lake. The Kaweah River is controlled by Terminus Dam and Reservoir. The average annual runoff at the edge of the foothills is about 404,000 acre-feet.

The Tule River has a watershed of 390 square miles above Success Dam, located near Porterville, with headwaters rising to an elevation of about 9,500 feet. There is about 34 percent of the drainage area above 5,000 feet. The alluvial fan of the Tule River is similar to those of other Sierra Nevada streams. Flood flows historically traversed the fan through several channels to terminate in Tulare Lake. The Tule River is controlled by Success Dam and Reservoir. The average annual runoff at Success Dam is about 136,000 acre-feet.

The Kern River is the most southerly of the major watersheds in the San Joaquin Valley. The watershed comprises an area of about 2,410 square miles and consists of two major drainage basins. The North Fork is the main watershed and extends northerly a distance of over 80 miles to the vicinity of Mount Whitney and other peaks in excess of 14,000 feet. More than 50 peaks in the basin have elevations in excess of 13,000 feet. The North Fork of the Kern River is controlled by Isabella Dam and Reservoir and the drainage area above the dam is about 2,100 square miles. The South Fork drains the eastern and southern part of the watershed with elevations much lower than the North Fork. About 72 percent of the Kern River watershed has an elevation in excess of 5,000 feet with most of the high elevation area on the North Fork. The two forks join above Isabella Dam and the river flows westerly through a rugged canyon to the Valley floor about 12 miles east of Bakersfield. The river then flows southwesterly across the Valley floor to Buena Vista Lake, or northward to Tulare Lake under higher flow conditions. The average annual

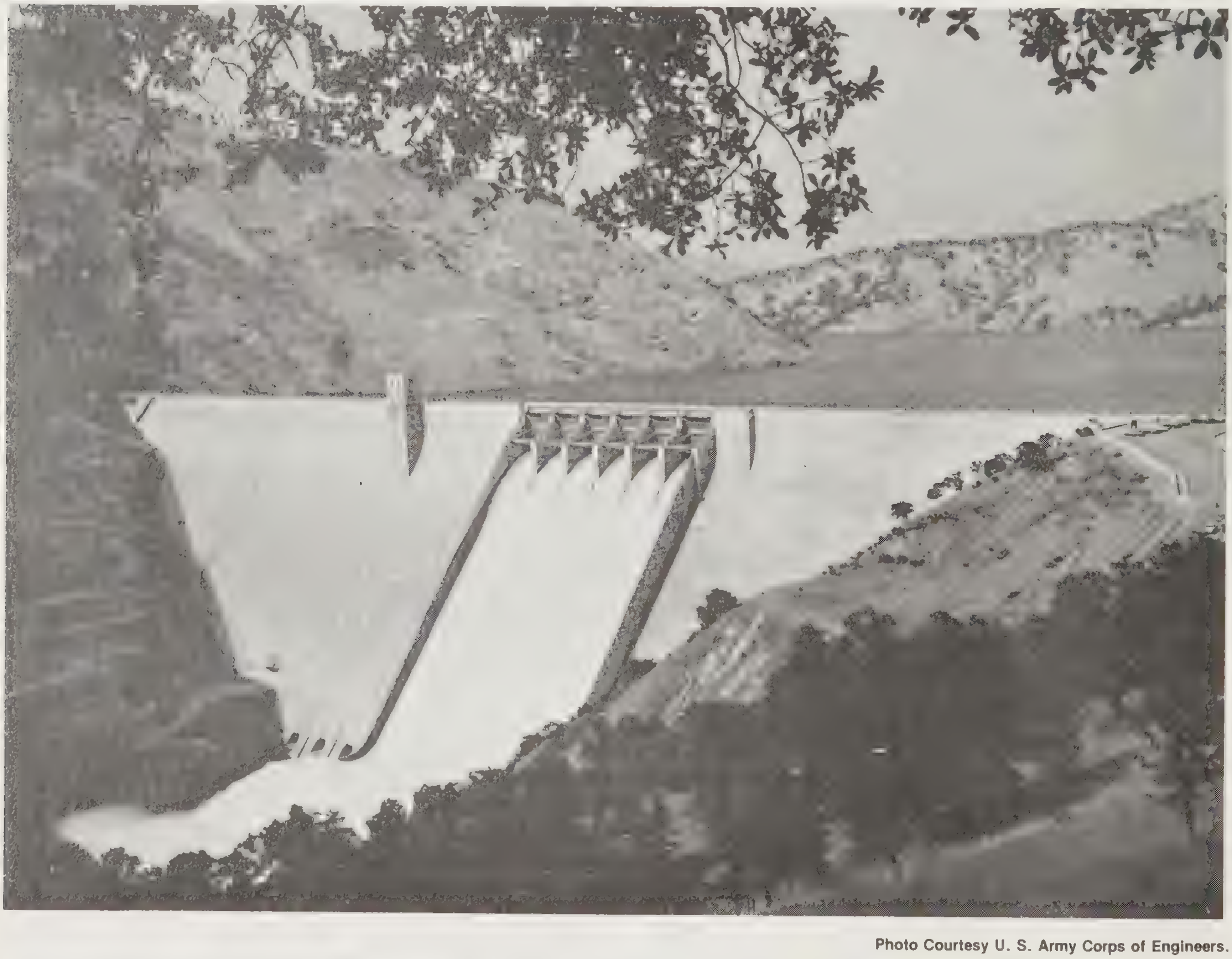


Photo Courtesy U. S. Army Corps of Engineers.

Pine Flat Dam on the Kings River provides essential flood control for prime agricultural land and urban areas; and regulated releases for irrigation and ground water recharge.

runoff of the Kern River is about 714,000 acre-feet and the runoff regimen is primarily that of a snowmelt stream.

Minor east-side streams drain the foothill areas between the major rivers. Some of these streams become tributaries of the major rivers under high flow conditions but generally disappear on the Valley floor. With the exception of the streams in the southern end of the Valley that flow from the Tehachapi Mountains, most of the watersheds are below 2,500 feet in elevation. Runoff is characteristic of rain-fed streams. Minor west-side streams that drain from the Coast Range contribute only small quantities of water to the Valley supply. Runoff frequently occurs during periods of short duration, however, and damage from flood flows occurs during some years. The total average annual runoff from the minor streams is about 315,000 acre-feet.

The total surface supply to the southern San Joaquin Valley from natural or unimpaired runoff is the supply that would occur unaltered by diversions, storage reservoirs or importation from other watersheds. Seasonal runoff varies widely from year to year. Estimates of mean annual runoff vary with the period of record or base period used. Table 5 summarizes stream runoff reaching the southern San Joaquin Valley. The mean annual runoff quantities shown in Table 5 are 97 percent of the annual mean amounts published in DWR Bulletin No. 1, "Water Resources in California", 1947, reflecting impairment due to reservoir evaporation and the additional period of record available since the date of that publication.

TABLE 5

MEAN ANNUAL RUNOFF OF STREAMS TRIBUTARY TO SOUTHERN SAN JOAQUIN VALLEY

Stream	Thousands of Acre-feet
Chowchilla River	71
Fresno River	100
San Joaquin River	1,762
Kings River	1,659
Kaweah River	404
Tule River	136
Kern River	714
Minor East-side Streams	268
West-side Streams	47
Total	5,161

Mean annual precipitation on the Valley floor varies from 5 to 10 inches. As occurs elsewhere in the Central Valley, there is a wide variation between wet and dry years. There is essentially no contribution to ground water from precipitation but there is some contribution to soil moisture for plant growth.

Surface Water Development

Early water resources development projects in the San Joaquin Valley made direct surface diversions from the stream systems to lands lying principally on the alluvial fans of major streams. These diversions utilized the runoff resulting from snowmelt which often diminished rapidly early or midway in the irrigation season. Minimal reservoir storage limited the amount of lands that could be served. Canal and ditch systems were developed to convey water to lands to the extent water was available. Artesian wells provided some of the supply to areas more distant from the streams. By the early 1900's, pumping had begun from some of the streams and extractions of ground water from wells had begun. By 1900, some 800,000 acres in the San Joaquin Valley were under irrigation although much of the land had inadequate water supplies. The rapid increase in irrigation during the first three decades of this century and the decline of ground water levels prompted studies of surface water development projects by the State of California.

Preparation of the State Water Plan and its authorization in 1931, led to the construction of the CVP. The State Water Plan called for construction of storage reservoirs on the rivers of the San Joaquin Valley and canals and conveyance systems in the Valley, including diversion and conveyance facilities from the Sacramento-San Joaquin Delta. Most of the works called for in the 1931 State Water Plan have been constructed, with some modifications, principally by the Corps of Engineers and the USBR. Multiple purpose reservoirs that have been constructed in the southern San Joaquin Valley are discussed below.

Buchanan Dam, about 16 miles east of Chowchilla on the Chowchilla River, was constructed by the Corps of Engineers and completed in 1977. The reservoir has a capacity of 150,000 acre-feet. Approximately 24,000 acre-feet of new water supply is being developed by the project through conservation of flood waters which would otherwise be lost to the Pacific Ocean, and increased ground water recharge from percolation of controlled reservoir releases.

Hidden Dam on the Fresno River, about 15 miles northeast of Madera, was constructed by the Corps of Engineers in 1977. Storage capacity of the reservoir is 90,000 acre-feet. A new water supply of about 24,800 acre-feet is being developed by conservation of flood waters.

Friant Dam on the San Joaquin River was constructed by the USBR and completed in 1944. This was the key facility in the San Joaquin Valley that made possible the first major interbasin transfer of water in the Central Valley. The reservoir, Millerton Lake, has a capacity of 520,000 acre-feet, of which about 400,000 acre-feet is usable. Water diverted through Friant-Kern and Madera Canals from Friant Dam is replaced to water right holders along the lower San Joaquin River, through an exchange contract, with water imported from the Delta. The Pacific

Gas and Electric Company and Southern California Edison Company have constructed additional reservoirs on the San Joaquin River, which have total storage capacity of 609,000 acre-feet, for hydroelectric power purposes.

Pine Flat Dam on the Kings River, about 25 miles east of Fresno, was completed in 1954 by the Corps of Engineers. It has a storage capacity of one million acre-feet. Although constructed primarily for flood control, there is some regulation of Kings River water used for local irrigation supply. Over one million acres of agricultural lands receive Kings River water.

Terminus Dam on the Kaweah River, about 20 miles northeast of Visalia, was completed by the Corps of Engineers in 1962. The reservoir has a capacity of 150,000 acre-feet. The reservoir provides some regulation of irrigation supplies with some increase in usable water supply through reduced inflow to, and evaporation from, Tulare Lake.

Success Dam on the Tule River is located about five miles east of Porterville and was completed in 1961 by the Corps of Engineers. The reservoir has a capacity of 85,000 acre-feet and provides approximately 6,000 acre-feet annually of new water supply because of reduced inflow to, and evaporation from, Tulare Lake during flood years. Some regulation of irrigation and ground water recharge supplies is also provided by the reservoir.

Isabella Dam on the Kern River is located about 35 miles northeast of Bakersfield. The dam was completed in 1954 by the Corps of Engineers and has a reservoir capacity of 570,000 acre-feet. There is some new water provided by the project as a result of less inflow to Buena Vista and Tulare Lakes and reduced evaporation loss. Irrigation supplies from the Kern River are regulated by the project.

Ground Water

The San Joaquin Valley is a geologic depression formed between two uplifted areas, the Coastal Mountain Ranges on the west and the Sierra Nevada to the east. A representative section of the Valley is shown on Plate 2 "Diagrammatic Profile of the Ground Water Basin." The depression has been filled by over 20,000 feet of sedimentary material, most of which is marine in origin and contains water too saline for domestic and agricultural use. The upper and most recently deposited Valley fill material consists principally of alluvial deposits which extend to depths of up to 3,000 feet. These alluvial deposits contain fresh water and comprise a vast underground reservoir beneath the San Joaquin Valley floor. It is estimated that over 150 million acre-feet of fresh water is stored in the underground reservoir to a depth of 500 feet.

The ground water reservoir in the Valley is, in large part, divided into an upper, unconfined aquifer system and a deeper, confined aquifer system, separated by a clay layer (Corcoran Clay) which extends beneath much of the San Joaquin Valley. These aquifers are depicted on Plate 2. The relatively shallow, unconfined portion of the ground water reservoir is replenished by infiltration from streamflow, artificial recharge, and return flow from applications of irrigation water. The deeper, confined aquifer system is replenished primarily by lateral flow of ground water from those portions of the unconfined aquifer systems along the easterly, westerly and southerly edges of the Valley which are not underlain by the Corcoran Clay. A small quantity of ground water percolates downward from the unconfined aquifer systems, through the Corcoran Clay and into the underlying, confined aquifer.

Within the basin, ground water moves generally from areas of major replenishment along the easterly margin of the Valley westerly to the trough of the Valley. A much smaller component of movement occurs from the westerly edge of the Valley, since the amount of replenishment available from the Coast Ranges is limited.

The mineral quality of ground water extracted for use in the Valley is generally satisfactory for irrigation of crops. The salinity of ground water typically increases in a westerly direction across the Valley, reflecting the relatively low salinity level of ground water replenished by surface waters originating in the Sierra Nevada, and the normal pick-up of salts which occurs as ground water moves westward through the subsurface deposits. A difference in mineral quality also exists between shallow and deep ground waters. For example, where return flows of irrigation water cannot percolate downward and mix freely with waters in the unconfined aquifer system, a salinity buildup is often associated with the development of shallow water tables in the perched aquifers.

Madera County

Ground water in Madera County occurs in an unconfined aquifer system throughout, and in a confined aquifer system beneath the Corcoran Clay, which occurs generally westerly of Highway 99. The surface soils and near-surface (10 to 50 feet) alluvial deposits underlying the northerly half of the County (between the Fresno and Chowchilla rivers) have generally low permeabilities, which tend to restrict the downward movement of water to the water table. The southerly portion of the County exhibits generally higher surface and subsurface permeability, thus providing somewhat better opportunity for recharge to the underground. The mineral quality of ground water in Madera County is generally suitable for most uses.

Fresno County

Fresno County is dominated by extensive alluvial fans associated with the San Joaquin and Kings rivers. These alluvial fan deposits are relatively permeable and provide

large areas where ground water can be, and is, readily recharged from the surface. The Corcoran Clay occurs beneath the approximate westerly one-third of the County and, as such, causes ground water beneath the Clay to be confined. The Fresno Slough area, extending northerly through the middle of the County between the Kings and San Joaquin rivers, is characterized by relatively impermeable surface and subsurface deposits, which impede the downward movement of water and cause a perched ground water condition, requiring extensive drainage of the land to prevent waterlogging of the soil. Ground water quality in the unconfined aquifers of the easterly two-thirds of the County, and in the confined aquifers of much of the area to the west, is generally good to excellent. In the shallower unconfined zones to the west and in some portions of the confined aquifers, ground water is generally marginal to unsatisfactory.

Tulare County

Ground water in Tulare County occurs in the unconfined state throughout, and in a confined state beneath the westerly half of the County. Extensive alluvial fans associated with the Kings, Kaweah and Tule rivers provide highly permeable areas in which ground water in the unconfined aquifer system is readily replenished. Interfan areas between the aforementioned streams contain less permeable surface soils and subsurface deposits, impeding ground water recharge and causing well yields to be relatively low. The mineral quality of ground water in Tulare County is generally satisfactory for all uses.

Photo Courtesy U. S. Army Corps of Engineers.

Two dams on the Kern River create Isabella Lake which provides flood control and regulated releases for irrigation and ground water recharge.

Kings County

Kings County occupies the westerly portion of the Valley and encompasses the bottom lands associated with Tulare Lake. Throughout the County, ground water is obtained from the confined aquifer system underlying the Corcoran Clay, and usable ground water is extracted from unconfined aquifers in the northeastern portion of the County. Tulare Lake bed is underlain by relatively impermeable surface soils and subsurface deposits, thus aquifers underlying a large portion of the County cannot be recharged from the surface, although there is recharge from the surface to the unconfined aquifers in the northeasterly area. Installation of subsurface drainage facilities has been necessary to control the shallow, perched ground water table. The mineral quality of ground water in the shallow, unconfined aquifers underlying extensive areas of the County is not suitable for agricultural or domestic use.

Kern County

Ground water occurs in both unconfined and confined aquifers in Kern County. Alluvial fan areas associated with the Kern River and Poso, Caliente and Tejon creeks provide extensive areas of absorptive surface and subsurface deposits which allow ground water to be easily replenished by percolation from the surface. Alluvial fan areas associated with minor streams along the southerly edge of the Valley also provide permeable areas suitable for artificial recharge of unconfined aquifers. Topographically low-lying areas around the westerly periphery of the fan areas, i.e., Kern Lake, Buena Vista Lake, Goose Lake and Buena Vista Slough, are underlain by relatively impermeable deposits which prevent significant ground water recharge and cause a shallow, perched ground water table to occur. The quality of ground water in Kern County is generally satisfactory, although the westerly portion of the County is underlain by ground water too saline for most uses.

The White Wolf Fault system, which extends across the southerly end of the San Joaquin Valley from the vicinity of Arvin to Wheeler Ridge, constitutes a relatively impermeable ground water barrier. This barrier separates the ground water body to the south, underlying some 50,000 acres of Valley land, from the ground water body underlying the rest of the Valley. Alluvial fan areas associated with minor streams along the southeasterly edge of the Valley provide permeable areas suitable for recharge of the ground water in the area to the south of this fault.

Recharge From Irrigation

The application of irrigation water to the nearly four million acres of crop land in the southern San Joaquin Valley is a major contributor to the ground water supply where there is hydraulic continuity between the ground surface and the principal aquifers. Geologic conditions that determine hydraulic continuity, and the extent to which these conditions enhance or impede the return to ground water, are extremely complex. The conditions of hydraulic continuity vary widely throughout the Valley and they are much less favorable on the west side. Determination of the amounts of recharge to ground water from irrigation is very complex and involved, not only because of the cited subsurface geologic conditions, but also because of other complexities such as the differing irrigation and drainage practices in the various portions of the Valley. The factors involved in such a determination were illustrated in the SWRCB Water Quality Plan for Basin 5-D, which recommended evaluation of the following factors for purposes of such a determination:

1. Irrigation efficiencies.
2. Areal extent of semi-impervious lenses.
3. Areal distribution of irrigated and non-irrigated lands.
4. Permeability of soil material.
5. Moisture control of the soil profile.
6. Seepage losses from surface stream flows and irrigation canals and ditches.
7. Quantities of flow through semi-impervious zones.
8. The horizontal (vs. vertical) movement of water due to semi-impervious lenses throughout the soil profile.
9. Transmissibility coefficients of soils.
10. Location, depth, and quantity of extraction from ground water.
11. Changes in static and piezometric levels of main ground water supply.
12. Quantity of deep percolation of precipitation.
13. Quantity of agricultural waste water to be removed from the water regime.

Ground Water Development

Under natural conditions that prevailed in the San Joaquin Valley prior to the 1850's, ground water moved from recharge areas along the sides of the Valley toward the low (central) portion where it discharged at the land surface by seepage and evapotranspiration. The great alkali areas of the southwestern and central parts of the Valley indicate natural discharge of ground water by evaporation, leaving salt accumulations in the surface soils.

Application of large quantities of surface water for irrigation had modified the natural ground water regime even before ground water was used for irrigation. Early irrigation with surface water raised ground water levels and resulted in serious damage in many irrigated areas by waterlogging and accumulation of alkali in the soils. This drainage problem was alleviated almost entirely by greater utilization of ground water for supplemental irrigation.

More than half a century after the first settlements were established, pumpage of ground water was still small in quantity. Widespread pumping in the San Joaquin Valley began about 1900 and in 1905-06, it was reported that between 500 and 600 flowing wells, and a somewhat greater number of pumped wells, were being operated. Ground water extractions in 1906 were estimated by Mendenhall to be about 225,000 acre-feet. By 1912, Harding and Robertson estimated the level of ground water extraction to be about 700,000 acre-feet per year. From 1930 to 1940, the level of ground water extraction remained stable at approximately two million acre-feet per year, but after 1940, extractions in the San Joaquin Valley increased at an accelerated rate. The USGS estimated that the total extractions of ground water in 1955 had reached nine million acre-feet per year, representing more than one-quarter of all ground water pumped for irrigation in the United States.

More recent estimates prepared by the USGS for the five-county area, Madera, Fresno, Kings, Tulare and Kern, indicate about 8.25 million acre-feet of ground water was extracted during 1966.

The diversion of surface water from streams and the development of ground water for irrigation have lowered ground water levels, changed hydraulic gradients (water level slopes) and, in some places, the direction of ground water movement. The recent changes in ground water levels are shown on Plate 3 "Change in Ground Water Levels, 1965-1975" and ground water conditions in 1977 are shown on Plate 4 "Depth to Ground Water in Fall 1977."

Imported Water

The transbasin diversion of water into the San Joaquin Valley from the Sacramento Valley was the principal concept upon which the CVP was founded. The transfer of water from the Delta to Mendota Pool on the San Joaquin River, through the Delta-Mendota Canal, as earlier mentioned, also made possible the redistribution of water for more effective use within the southern San Joaquin Valley through water transfers in the Friant-Kern and Madera Canals. Subsequently, the California Aqueduct of the SWP provided for transfer of additional imported water from the Delta, and the Cross Valley Canal provided for transfer of imported water from the California Aqueduct to east Valley areas. The storage and conveyance facilities that implemented these transfers are discussed below.

Delta-Mendota Canal

The Delta-Mendota Canal conveys water from the Delta to Mendota Pool on the San Joaquin River 117 miles to the south to provide San Joaquin River water rights and exchange water, supplemental water supply to agricultural lands along the west side of the San Joaquin Valley from Tracy to Mendota, and San Luis Project water. The latter is supplied from the Delta to O'Neill Forebay where it is pumped into San Luis Reservoir or into the San Luis Canal for the Federal San Luis Unit of the CVP. Beginning in 1976, additional CVP water was diverted into the Delta-Mendota Canal, and from this canal to the California Aqueduct, to supply water to the eastern part of the southern San Joaquin Valley through the Cross Valley Canal of the Kern County Water Agency. The capacity of the Delta-Mendota Canal at the Delta is 4,600 second-feet and at its terminus 3,200 second-feet. The average annual diversion from the Delta through the Canal is about three million acre-feet.

Water delivered from the Delta-Mendota Canal under long-term agreements is done so under three general arrangements. These are an exchange contract, water rights settlements and a water contracting program.

One of the basic concepts of the operation of Millerton Lake, with diversions at Friant Dam into the Madera and Friant-Kern Canals, was for the United States to acquire certain water rights on the San Joaquin River and Fresno Slough. Also, it was agreed that water would be imported from the Delta and delivered into the San Joaquin River at Mendota Pool, near the town of Mendota, in exchange for San Joaquin River water diverted at Friant Dam. This Exchange Contract water amounts to 840,000 acre-feet per year and is diverted and distributed by several canal companies and the Central California Irrigation District. Approximately 290,000 acre-feet of this exchange water is used in Fresno County and the balance in Merced and Stanislaus counties.

Additional water requirements of 32 water contracting districts along the Delta-Mendota Canal from Tracy to Mendota are being served by the USBR through its water contracting program. Water delivery commitments from the Delta-Mendota Canal for these contractors total about 537,000 acre-feet per year, in addition to about 106,000 acre-feet delivered for miscellaneous purposes. Some of the water applied to lands in the service area is pumped from return flow systems for reuse. Surface drains are used to convey some drainage water out of the area for use in the Grasslands Water District in Merced County. Water delivery commitments from the Delta-Mendota Canal into Fresno County under long-term water service contracts amount to 202,400 acre-feet per year, as summarized in Table 6.

In addition to the foregoing, there are annual water delivery commitments into Mendota Pool from the Delta-Mendota Canal to satisfy prior water rights of James Irrigation District (45,000 acre-feet) and Tranquillity Irrigation District (34,000 acre-feet), and for a portion of contract water for Westlands Water District (50,000

Photo Courtesy U.S. Bureau of Reclamation.

Water pumped from the Sacramento-San Joaquin Delta flows into O'Neill Forebay from the California Aqueduct and by pumps from the Delta-Mendota Canal on the right. It leaves through the San Luis Canal on the left. Water is also pumped into San Luis Reservoir in the background and released back into O'Neill Forebay when needed for irrigation.

TABLE 6

LONG-TERM CONTRACT WATER ENTITLEMENTS FROM DELTA-MENDOTA CANAL FOR AGENCIES IN FRESNO COUNTY

Agency	Maximum Annual Water Entitlement (Acre-Feet)
Broadview Water District	27,000
Eagle Field Water District	4,550
Mercy Springs Water District	13,300
Oro Loma Water District	4,600
Pacheco Water District	10,080
Panoche Water District	66,800
San Luis Water District	73,080
Widren Water District	2,990
Total	202,400

acre-feet) for a total of 129,000 acre-feet per year.

A summary of contractual water entitlements for deliveries in Fresno County from the Delta-Mendota Canal (excluding water transferred to San Luis Reservoir and San Luis Canal) is presented following:

	Thousands of Acre-feet Per Year
Exchange Contract	290
Contracting Program	194*
Water rights and Westlands W.D.	129
Total	613

*Reduced to account for water delivered to lands in Merced County.

San Luis Canal

The San Luis Canal is a joint Federal-State unit of the California Aqueduct as described later in this section. Entitlements of Federal water contractors for deliveries from the San Luis Canal are summarized in Table 7.

TABLE 7

LONG-TERM WATER CONTRACT ENTITLEMENTS FROM SAN LUIS CANAL

Agency	Maximum Annual Water Entitlement (Acre-feet)
Avenal Community Services District	3,500
City of Coalinga	10,500
City of Huron	3,000
Panoche Water District	27,200
San Luis Water District	52,000*
Westlands Water District	1,100,000**
Losses	59,000
Total	1,255,200

*An estimated 25,000 acre-feet per year is delivered in Fresno County and the balance in Merced County.
**Subject to completion of negotiations.

Friant-Kern Canal

The Friant-Kern Canal diverts from Friant Dam and extends southward a distance of 153 miles through Fresno, Tulare and Kern counties to its terminus in the Kern River near Bakersfield. The capacity at the inlet is 5,000 second-feet. The available water supply on the San Joaquin River has been used very effectively through the USBR's water contracting program that provides for the sale of Class 1 and Class 2 water. Class 1 water is a relatively firm supply of about 800,000 acre-feet per year, with additional Class 2 water in the wetter years of up to 1.0 million acre-feet. The total Class 1 and 2 water delivered in an average year is about 1.4 million acre-feet. Class 2 water is used either directly for irrigation or for ground water recharge. Agencies with contracts for delivery of Class 2 water use the additional water for recharge through spreading operations or to reduce ground water pumping. A summary of the long-term contracts for Class 1 and Class 2 Friant-Kern Canal water is shown in Table 8.

TABLE 8

LONG-TERM CONTRACT WATER ENTITLEMENTS FROM FRIANT-KERN CANAL

	Maximum Annual Water Entitlement (Acre-Feet)	
Agency	Class 1	Class 2
Arvin-Edison W.S.D.	40,000	313,000
Delano-Earlimart I.D.	108,800	74,500
Exeter I.D.	11,500	19,000
Fresno, City of	60,000	0
Fresno I.D.	0	75,000
Garfield W.D.	3,500	0
International W.D.	1,200	0
Ivanhoe I.D.	7,700	7,900
Lewis Creek W.D.	1,450	0
Lindmore I.D.	33,000	22,000
Lindsay-Strathmore I.D.	30,000	0
Lower Tule River I.D.	61,200	238,000
Orange Cove, City of	1,400	0
Orange Cove I.D.	39,200	0
Porterville I.D.	16,000	30,000
Round Mountain Ranch	90	0
Saucelito I.D.	21,200	32,800
Shafter-Wasco I.D.	50,000	39,600
So. San Joaquin M.U.D.	97,000	50,000
Stone Corral I.D.	10,000	0
Tea Pot Dome W.D.	7,500	0
Terra Bella I.D.	29,000	0
Tulare I.D.	30,000	141,000
Total Entitlement	659,740	1,042,800

Madera Canal

The Madera Canal is 37 miles in length and extends northward from Friant Dam to its terminus at Ash Slough, a tributary of Chowchilla River. The capacity at the point of diversion is 1,250 second-feet. Approximately 320,000 acre-feet of San Joaquin River water is delivered in an average year to lands in Madera County. The long-term contracts for Class 1 and Class 2 water from the Madera Canal are shown in Table 9.

TABLE 9

LONG-TERM CONTRACT WATER ENTITLEMENTS FROM MADERA CANAL

	Maximum Annual Water Entitlement (Acre-feet)	
Agency	Class 1	Class 2
Chowchilla Water District	55,000	134,000
Madera Irrigation District	85,000	186,000
Total Entitlement	140,000	320,000

California Aqueduct

The California Aqueduct is the major conveyance feature of the SWP. It diverts water from the Delta and, after crossing the Tehachapi Mountains, splits into two branches with one terminus in Riverside County and the other terminus in Los Angeles County near Castaic. The total length of the two components is 572 miles, mostly in canal section. The Aqueduct has a capacity of 10,000 second-feet from the Delta to O'Neill Forebay 64 miles to the south.

The joint Federal-State San Luis Unit of the CVP is incorporated into the California Aqueduct System and includes O'Neill Forebay, San Luis Dam and pump-generating facility, Dos Amigos Pumping Plant and San Luis Canal. The San Luis Canal portion of the California Aqueduct carries both CVP and SWP water from San Luis Reservoir to Kettleman City, a distance of 106 miles, where it becomes a State-only facility. A coastal branch commences at Avenal Gap and will ultimately be extended into San Luis Obispo and Santa Barbara counties.

The California Aqueduct conveys water to agencies in the San Joaquin Valley and southern California that have contracts for water from the SWP. These contracts place an obligation on each of the water contracting agencies to repay: (1) its allocated share of capital investment in transportation facilities; (2) the cost of water conservation facilities through a Delta water charge on each acre-foot of its entitlement water under the contract; and (3) its share of operation, maintenance and power costs. The agencies are obligated to all costs except variable operation costs, whether or not they receive any water.

The contracts include a schedule of entitlement water which the State is obligated to deliver each year. This schedule, known as "Table A", builds up each year to a maximum annual entitlement in 1990. The contracts also provide for the delivery of certain quantities of surplus water, in addition to entitlement water, when such water is available. This water, which is delivered at a reduced rate, reflecting mostly incremental operating costs, was intended to reduce the overall costs of water supply to agricultural water agencies and to encourage the use of project water for ground water recharge during early years of project operation.

The surplus water program was a response to a resolution of the Legislature (ACR 93) in 1963. Surplus water accomplishes essentially the same purpose as Class 2 water from the Friant-Kern Canal in that it provides for ground water replenishment by agencies that can reduce pumping in years when such water is available.

The maximum annual entitlements of water agencies in the southern San Joaquin Valley for water delivered through the California Aqueduct as shown in Table 10.

TABLE 10
CONTRACT ENTITLEMENTS TO SWP WATER IN THE SOUTHERN SAN JOAQUIN VALLEY

Agency	Maximum Annual Entitlement (Acre-feet)
Devils Den Water District	12,700
Dudley Ridge Water District	57,700
Empire West Side Irrigation District	3,000
Hacienda Water District	8,500
Kern County Water Agency	1,153,400
County of Kings	4,000
Tulare Lake Basin Water Storage District	110,000
Total Entitlement	1,349,300

Cross Valley Canal

The Cross Valley Canal, constructed in Kern County in 1975 by a group of agencies in Kern, Tulare and Fresno counties, interconnects the California Aqueduct of the SWP on the west side of the Valley and the Friant-Kern Canal of the CVP on the east side of the Valley. In addition to conveying SWP water to Bakersfield and adjacent areas, it also serves the purpose of conveying CVP water, wheeled through the California Aqueduct from the Delta, to benefit Federal water contractors on the east side of the San Joaquin Valley through exchange agreements. Further discussion of this program is contained in Chapter VI of this report. Water imported through the Cross Valley Canal under the exchange agreements is 128,300 acre-feet annually.

Water Supply-Water Disposal Relationship

The water supply-water disposal relationship is the basis for determining basin-wide water balance for the long term. This relationship refers to a comparison of the summation of long-term averages of items of water supply, and the summation of current or projected levels of items of disposal. The difference is surplus or deficiency. A surplus would indicate that local surface water supplies and water imports through the CVP and SWP are positive acretions to the ground water basin. A deficiency would represent the magnitude of the supplemental water demand, also indicating that extractions from ground water exceed recharge, a condition of overdraft.

An analysis of water supply and disposal was prepared for this study, based upon available data on water supply and utilization summarized previously in this chapter, and estimates of items for which measurements or other record data are not available. The analysis of water supply and disposal in the southern San Joaquin Valley is presented in Table 11 for conditions of present development and conditions expected in the year 2000 without additional import projects.

Photo Courtesy U.S. Bureau of Reclamation.

The San Luis Drain of the Central Valley Project must be extended southward to convey brackish drainage water out of the Valley and prevent adverse salt balance.

The items of water supply in Table 11 include stream runoff (reference Table 5) from which surface outflow from tributary streams is deducted. This surface outflow constitutes that portion of the flows of the San Joaquin, Chowchilla, Fresno and Kings rivers which cannot be controlled for diversion to use or recharge within the study area. The other items of water supply are the amounts previously shown to be imported through State and Federal facilities.

The items of disposal in Table 11 include net water use by agricultural and urban developments as summarized previously in this chapter.

A precise determination of other items of disposal, particularly drainage, is difficult. This is partly because of the extensive area of application of irrigation water (nearly four million acres) and the percolation of water from that area to the ground water basin through the complex and variable geologic strata as mentioned previously. In any year, there are over four million acre-feet of water in the relatively slow process of vertical and lateral movement, for, not only is the ground water basin a storage reservoir, it is also an enormous transmission medium in the zone of alluvial materials between the ground surface and the ground water table. Outflow as drainage from the study area resulting from irrigation return flows is not measured, but is estimated to be about 70,000 acre-feet per year from the application of irrigation water in Fresno County north of Mendota. Additional loss from the basin is the evaporation of excess flood waters ponded in Tulare Lake in certain years, which averages about 30,000 acre-feet per year. Thus, the total of evaporation and drainage loss is about 100,000 acre-feet per year.

Agricultural waste water directly removed from the basin was previously estimated to be 3,000 acre-feet per year as evaporation from ponds, and it was further indicated that some 230,000 acre-feet of such waste water must be removed in the future to prevent adverse salt balance.

Table 11 indicates an average annual water supply deficiency of about 1.4 million acre-feet and an estimated year 2000 deficiency of about 1.7 million acre-feet. The indicated present deficiency of water supply is being met from ground water overdraft. The Table 11 analysis assumes delivery from SWP of Table A entitlements, which are indicated to be some 635,000 acre-feet per year greater in year 2000 than at present. It is estimated that the ground water deficiency under present conditions could be reduced to about 900,000 acre-feet per year with full delivery of 1990 entitlement water from the SWP. This estimate recognizes that some 465,000 acre-feet per year of the additional SWP water would be used on lands which overlie ground water and would, therefore, replace ground water pumping.

TABLE 11

WATER SUPPLY AND DISPOSAL IN THE SOUTHERN SAN JOAQUIN VALLEY

[1,000 Acre-feet]

Item	Present	Year 2000
Water Supply		
Stream Runoff	3,265	3,265
Friant-Kern Canal	1,394	1,394
Madera Canal	320	320
Delta-Mendota Canal	613	613
San Luis Canal	1,228	1,228
Cross Valley Canal	128	128
California Aqueduct	704	1,349
Total Supply	7,652	8,297
Water Disposal		
Agricultural Use	8,728	9,356
Municipal and Industrial Use	234	320
Evaporation and Drainage	100	100
Agricultural Waste Water	3	232
Total Disposal	9,065	10,008
Overdraft		
Water Supply Deficiency (Overdraft)	1,413	1,711

CHAPTER V

FUTURE AVAILABILITY OF IMPORTED WATER

Availability of imported water to meet demands in the southern San Joaquin Valley, as elsewhere in the State, must be viewed from the standpoint of historical policies and current social, political, environmental and economic constraints. The Legislature has enunciated policy concerning the development and use of water in California in Water Code Section 10005 (added by Statutes of 1959 Chapter 2053,Section 2,Page 4748), by declaring:

"........ it is the policy of the State that The California Water Plan, with such amendments, supplements and additions thereto as may be necessary from time to time, is accepted as the guide for the orderly and co-ordinated control, protection, conservation, development, and utilization of the water resources of the State."

The California Water Plan, referred to in said policy, published in 1957 as Bulletin No. 3 by the DWR, summarized the water problems of California including this statement:

"California's water problems result primarily from the unbalanced distribution of its water resources and water requirements. The major sources of water are in northern California where the waters of many streams now waste into the ocean virtually unused. The major urban areas and productive agricultural lands of California are in that portion of the State to the south in which occurs only 30 per cent of the total natural runoff. Great distances and rugged mountains separate source areas from areas of demand. About 70 per cent of the total stream flow occurs north of the latitude of Sacramento, but 77 per cent of the present use of water, and 80 per cent of the forecast ultimate use lie south of that line."

The California Water Plan outlines measures for implementation of the Plan, including (on Page 244) the following legislative objective:

"a. The adoption of a proper constitutional amendment and implementing legislative enactments which must provide: (1) positive assurance to the areas of origin that adequate water will be reserved for their future development; (2) positive assurance to the areas of deficiency that when they contract with the State for water they can depend upon the right to that supply; (3) removal of the uncertainty inherent in existing statutes; and (4) an adequately financed, continuing program of water development to meet the needs for water in all areas of the State, as those needs arise and as projects to satisfy them are found to be feasible.

"b. The definition and determination of the nature and extent of vested rights to the use of surface and ground water, and the establishment of methods and procedures by which such rights as are affected may be compensated or otherwise adjusted in order to permit full operation of the Plan, including conjunctive operation of surface and groundwater basins; . . ."

Among the conclusions of The California Water Plan was the following:

"The waters originating in California, together with the rights of California in and to waters of the Colorado River, are adequate in quantity and quality to satisfy all water requirements of the State after it has reached full development, if the waters are properly controlled, conserved, protected, and distributed."

Planning and development of water projects such as those articulated in The California Water Plan has been pursued much earlier than the 1959 adoption by the Legislature. The first major import project was in 1915, when the Los Angeles Aqueduct was completed to import Owens River water into the City of Los Angeles. Other such projects in southern California and the San Francisco Bay area soon followed. First importation into the San Joaquin Valley began in 1951 with completion of the Delta-Mendota Canal. A comparison of imported water use in the three major import areas for 1972 is shown in Table 12 as derived from DWR Bulletin 160-74, "The California Water Plan, Outlook 1974".

TABLE 12

1972 USE OF IMPORTED WATER IN SELECTED AREAS OF CALIFORNIA COMPARED WITH TOTAL USE

[Acre-Feet]

Hydrologic Area	Imported Supply	Total Use	Percent Imported
San Francisco Bay	891,000	1,270,000	70
Southern California	1,819,000	3,030,000	60
San Joaquin Valley*	3,120,000	11,950,000	26

*Includes San Joaquin and Tulare Basins

1972 is the year that data common to all areas was available. The percentage of imported water use for all areas has increased since 1972. For the southern San Joaquin Valley, imported water is now about 30 percent of the net water demand.

Future availability of imported water from the CVP and SWP at any given point in time depends primarily on the

availability and operation of water storage and conveyance facilities and administrative policies and decisions respecting these facilities. While there are some risks and uncertainties in precipitation and runoff, years, and periods of years, of extreme drought have been experienced. The limited water supplies which occur in such periods can be managed to meet overall water needs with adequate facilities and administrative decisions. This chapter summarizes policies and concepts which affect the CVP and SWP operations, and presents estimates of project water yield capabilities as they relate to these policies and concepts. Also included is a discussion of possible developments to provide additional water yield capability.

Historical Policies

In planning for the SWP, certain concepts and policies provided the basis for project formulation. The water supply and power contracts of the Project, the project works to be built and the plan of operation, were based on these policies. Three of these interrelated policies are the Delta Pooling Concept, the Coordinated CVP-SWP Operation Agreement, and the Area of Origin and Delta Protection Statutes. The CVP was formulated and has been operated under principles of the Delta Pooling Concept and the Coordinated CVP-SWP Operation Agreement. Water rights granted by the SWRCB have reflected the Area of Origin and Delta Protection Statutes.

Delta Pooling Concept

The Delta Pooling Concept is based on storing water in certain reservoirs tributary to the Delta in wet periods to augment natural uncontrolled flows to the Delta during dry periods. The concept reflects the fact that as upstream development continues to occur, primarily in the Sacramento Valley, inflow to the Delta during dry periods would decrease. For the SWP, it was determined that in the earlier years of project operations release of stored water from Oroville and San Luis reservoirs, together with other regulated and unregulated inflows to the Delta, would satisfy water demands. As these demands built-up and depletions in the Sacramento Valley increased, it was expected that additional conservation facilities upstream from the Delta would be built and operated to release water into the Delta and maintain the project yield. For the CVP, the USBR has generally identified increments of project yield for service areas when documents for authorization of additional units were submitted to the Congress. The contract for water service from the San Felipe Unit, however, is for water from the Project without specific reference to a unit source.

Coordinated CVP-SWP Operation Agreement

During the late 1950's, the DWR and the USBR conducted negotiations concerning water supplies in the Delta. These negotiations were undertaken to avoid lengthy adjudication or litigation over State and Federal water rights. An agreement was signed on May 16, 1960, that provided the basis for coordinated operation of the two projects without respect to their relative water rights. A major feature of the agreement was the provision for allocating shortages of water supplies. It did not provide for the day-to-day project operations.

The need for daily operational coordination was recognized in the December 1961 agreement between the DWR and the USBR for construction of the San Luis joint-use facilities. After years of protracted negotiations, an agreement was reached with a draft document dated May 13, 1971, known as the Coordinated CVP-SWP Operation Agreement. This draft has never been signed by the Secretary of the Interior because of a lawsuit filed against the United States by the Environmental Defense Fund claiming no environmental impact statement had been prepared on the contract. In the meantime, however, the two agencies have been using the draft agreement on a year-to-year basis as a guideline for day-to-day operations.

Area of Origin and Delta Protection Statutes

Protection for the areas in which the water supplies originate is contained in several sections of the California Water Code. Water Code Section 10500 et seq protects the county in which the water originates by reserving unappropriated water for future use in accordance with statewide plans. This is known as the County of Origin Statute. When the State Central Valley Project Act was adopted in 1933, a provision was included that the watershed or area of origin should not be deprived of the prior right to all the water reasonably required for beneficial needs. This is contained in Water Code Sections 11460-11463 and is known as the Watershed Protection Act.

In 1959, the Legislature enacted a policy regarding protection for the Sacramento-San Joaquin Delta (Water Code Section 12200 et seq). This policy declares that salinity control is a function of the SWP in coordination with the CVP and that there should be no diversion of water from the Delta to which the users within the Delta are entitled. It was not intended that benefits received as a result of project operation should be provided free of charge. The Delta Protection Act refers to Water Code Section 11462 which states that the State is not required to furnish water to any person without adequate compensation. The question of Delta entitlements and level of benefits have later become the crux of much dispute,

particularly in critically dry years such as 1976 and 1977. The recent decision of the SWRCB, D-1485, incorporated the concept of the Delta entitlement based on pre-CVP and pre-SWP conditions. While the quantities of water involved are not yet decided, the pre-project basis of Delta water rights is a major policy position of the Board.

Water Rights

Future availability of water for the Valley will depend very heavily on the outcome of current water rights issues which are in various stages of challenge and resolution, in litigation and in administrative interpretation.

On April 14, 1973, the SWRCB issued its decision D-1422 on the application of the USBR for the New Melones Project. The decision placed a limit on the amount of storage in the reservoir as one of many conditions on the water rights permits. The permits authorized the use of water for consumptive purposes only in the counties of Stanislaus, Calaveras, Tuolumne, and San Joaquin. The permit order stated: "A petition to amend the permits to include other specific areas will be considered by the Board upon a showing that water from other CVP sources is not available to serve such areas."

The authority of the SWRCB to condition the permits of Federal water projects was questioned and as a result, the SWRCB requested the Federal District Court to issue a declaratory judgment as to the application of the prescribed conditions to the USBR. The United States reacted by bringing an action against the State in *USA v. California*, contending that the conditions on water rights could not be imposed upon the United States. The District Court and the Court of Appeals held that the State must grant the application for water by the United States if there is unappropriated water. The decision of the lower courts was reversed by the U. S. Supreme Court which found that a state may impose any condition on control, appropriation, use or distribution of water in a Federal reclamation project that is not inconsistent with clear Congressional directives respecting the project. The case has been remanded to the District Court to consider the permit conditions in the context of the Congressional authorization.

The SWRCB in its recent Decision 1485 (D-1485), which embraced an updated water quality control plan for the Delta, under authorization of the State Porter-Cologne Act and under Federal Public Law 92-500 mandate, includes water quality standards which will require release of stored water from both SWP and CVP reservoirs for salinity control in the Delta. The USBR has for many years maintained it is not authorized to provide salinity and water quality control in the Delta beyond that incidental to operation for export of water, unless the costs of the additional water quality control are reimbursed by the beneficiaries. The SWRCB D-1485 has been challenged and a number of lawsuits are pending. The office of the Secretary of the Interior has had under review its position with respect to *USA v. California* and the operation of the CVP.

On January 2, 1979, the Secretary of the Interior announced that the USBR would comply with the Delta water quality criteria in D-1485 in the operation of the CVP. The effect on CVP yield as a result of this position has not been announced, although the staff of the USBR has made some studies of the impact of D-1485. These studies indicate that the loss of combined yield to the CVP and SWP would be about one million acre-feet per year. The loss to the CVP would be about 600,000 acre-feet and the SWP loss about 400,000 acre-feet per year. This loss of yield comes from two causes, more stringent Delta water quality criteria and certain recently adopted operating criteria found to be applicable as a result of recent experience in project operations.

The estimated SWP and CVP yields in recent years have been based on Delta water quality standards set forth in a memorandum of agreement, dated November 19, 1965, between Federal, State and local agencies, on Delta water quality criteria. While this agreement was structured to protect Delta agriculture, it provided only incidental fishery protection and enhancement. Higher Delta outflows are required to meet higher water quality criteria set by D-1485. Experience during the drought of 1976-1977 showed that higher Delta outflow is required under long-sustained periods of reduced inflow to protect the water quality at the diversion pumps of the CVP and SWP in the southern Delta.

Central Valley Project Supplies

The availability of imported water from the CVP is determined by an analysis of project yield that relies on many assumptions, some of which are subject to change. For several years the USBR has indicated a firm CVP yield in excess of current demand and current commitments.

The USBR, in its Working Document 9, "Interim Water Supply, Total Water Management Study for the Central Valley Basin", March 1976, described its CVP yield studies and results thereof. Reservoirs assumed in operation in these earlier yield studies included Shasta, Whiskeytown, Black Butte, Folsom and Auburn in the Sacramento Valley; Clair Engle on the Trinity River; and New Melones, Millerton and San Luis in the San Joaquin Valley. The assumptions included the Peripheral Canal in operation by 1985, and a Delta outflow of 2,500 second-feet to maintain adequate protection to agriculture throughout the Delta.

It was estimated in these earlier yield studies that demands for project water would not exceed available supplies until sometime after the year 2000. Interim project supply could be available in the Delta even under dry year conditions for potential service areas not under long-term contracts. The USBR estimated that the CVP

facilities produced an annual yield of 9.25 million acre-feet. This estimate reflected reuse of water in areas upstream of the Delta, operation of Auburn Reservoir and pre-drought estimates of outflow needed to control water quality at the Tracy and Contra Costa Canal pumping plants.

The long-term contractual obligations, as of the year 1975, used in these earlier estimates by the USBR, amounted to about 6.61 million acre-feet, listed by service areas following:

Service Area	Acre-feet per year
Sacramento Valley	2,599,000
American River	833,000
Delta Diversions	3,175,000
Total	6,607,000

The 2.64 million acre-feet per year difference between estimated project yield (9.25 million acre-feet) and that supplied to service areas (6.61 million acre-feet) was available for future water service areas and increased demand under existing contracts. It was out of this supply that the USBR planned to meet demands of 216,000 acre-feet per year in the San Felipe service area in Santa Clara and San Benito counties, and 650,000 acre-feet per year in the San Joaquin Valley through the proposed Mid-Valley Canal.

Recent events, including the 1976-1977 drought, D-1485, and other Federal and State Administrative actions, caused the USBR to make a reanalysis of project yield in 1978. The assumptions used in the 1978 analysis included the following:

(a) 1976-1977 drought requires the CVP and SWP to allocate to the Delta for outflow and channel depletions, more water than was allocated in earlier studies. Delta outflow of up to 3300 second-feet replaced the earlier estimate of 2500 second-feet to meet the water quality objectives contained in the Bureau's Mendota Pool contracts.

(b) The Peripheral Canal not operational, and Auburn Dam not constructed.

(c) New Melones yield would be used upstream of the Delta and not available in the Delta, except that fish releases of 98,000 acre-feet in all but critically dry years would be available in the Delta to support the CVP yield.

As a result of the reanalysis, the USBR indicated the CVP yield is reduced from 9.25 to 7.92 million acre-feet per year. There will be a further reduction in CVP yield, however, as a result of the recent announcement of the Secretary of the Interior that the CVP will provide substantial additional Delta outflow as required by D-1485. The amount of reduction would depend on several assumptions which, for the purposes of this report, can only be approximated.

When SWRCB Decision 1379 was adopted in 1971, the terms and conditions were the most far reaching and significant of any water rights decision to that time. In a request for reconsideration of D-1379, the DWR stated that the loss of yield would be more than 1.5 million acre-feet per year from the combined CVP and SWP, of which the CVP share would be about 0.9 million acre-feet with a Peripheral Canal in operation. At that time, the USBR studies reported a combined project yield loss of about 2.1 million acre-feet per year. Decision 1379 was stayed by both Superior Court and Federal District Court as a result of litigation.

The loss of yield as a result of D-1485 is less than with D-1379, which it replaced, because of dry and critical year relaxation included in D-1485. Discussions with staff of the USBR indicate that the CVP loss to meet D-1485 may be about 600 thousand acre-feet. This would further reduce the CVP yield to 7.32 million acre-feet per year.

At this time, obligations of long-term contracts for CVP water from, and upstream of, the Delta amount to 7.28 million acre-feet per year. A summary of existing long-term CVP obligations is shown by service area as follows:

Service Area	Maximum Annual Obligation (Acre-Feet)
Sacramento Valley	3,252,800
American River	837,000
Delta Export	3,187,900
Total	7,277,700

The remaining unobligated CVP yield is about 640,000 acre-feet per year, as shown in Table 13 (supplied by the USBR) which does not reflect the additional loss of about 600,000 acre-feet resulting from the announcement of the Secretary of the Interior on D-1485. Based on this announcement, it appears that the existing long-term contractual commitments for the CVP are essentially equal to the existing project supply.

State Water Project Supplies

The features of the SWP, as authorized by the Burns-Porter Act, were planned to be constructed on a schedule as needed to meet the increasing contractual water demands. The staging of these features recognized the depletion of inflow to the Delta that would occur as a result of upstream water use. The California Aqueduct, with its enroute storage reservoirs and branch aqueducts and conservation storage in Lake Oroville and San Luis Reservoir, comprise the initial features.

In the early planning, it was expected that addition of the Delta facilities and import facilities from the North Coast would provide for meeting all of the contractual water supply obligations of the State. In accordance with the Burns-Porter Act, the Director of Water Resources designated the Peripheral Canal as the Delta facility and the Upper Eel River Development as the additional water development to maintain the project yield. The subse-

TABLE 13
CENTRAL VALLEY PROJECT
1978 INTEGRATED CVP YIELD

	Acre-Feet Per year
1969 CVP Yield	9,250,000
Less Auburn Dam Yield	—320,000
Less CVP share of increased allocation for Delta water Quality maintenance 1/	—630,000
Less return flows and deficiency credits from previously planned CVP service areas (Delta equivalent conversion)	—380,000
1978 CVP Yield	7,920,000
Existing CVP obligations	7,280,000
Remaining unobligated CVP Yield 2/	640,000

1/CVP share assumed to be 60 percent as required by existing Coordination Agreement. The Coordination Agreement and the CVP and SWP respective shares is being renegotiated.

2/The CVP has very little flexibility remaining. Future problem areas such as increased Trinity River releases for instream fishery uses could further reduce the 640,000 acre-feet and CVP operational flexibility.

(Source: USBR)

quent water rights decisions requiring higher water quality criteria for the Delta will commit some of the stored yield of Lake Oroville to Delta water quality and reduce the exportable supply. The Legislature enacted Wild and Scenic Rivers legislation in 1972, which casts some doubt on development of the Eel River unless it is removed from its Wild and Scenic River status. That legislation requires the DWR to report to the Legislature, by 1984, on the need for

Photo Courtesy U.S. Bureau of Reclamation.

Four emitters in plastic pipe permit careful control of water applied to an almond tree in an orchard irrigated by drip irrigation.

water supply and flood control projects on the Eel River.

The SWP yield is determined by the relationships among water demands, available water supplies, and the capabilities of the conservation facilities. It is not a static quantity but reflects conditions at one point in time. As noted in the discussion of the Delta Pooling Concept, the water supply in the Delta is ever-changing as upstream use changes. Under the utility framework, all water in the Delta which is unused or not needed for current commitments, including that from CVP, is available for project purposes.

Future project yield is a theoretical quantity that is dependent upon numerous assumptions and constraints. In DWR studies made at the time of passage of the Burns-Porter Act in 1959, a project yield of about 3.5 million acre-feet per year was expected with Oroville, San Luis and Delta transfer facilities in operation. The addition of the Middle Fork Eel River in the mid 1980's was planned, to add another 800,000 to 900,000 acre-feet per year of yield. This total yield was assumed to decrease with time as water use in the Sacramento Valley increased. It was contemplated that projects on the Trinity and Klamath rivers would be added in later years to maintain a project yield of four million acre-feet. The timing of development on the Trinity and Klamath rivers was based on a much more rapid growth rate for California than is now occurring and was more uncertain than the Middle Fork Eel River development.

In the prototype water service contract with Metropolitan Water District (MWD), the term "minimum project yield" was defined as ". . . the dependable annual supply of project water to be made available, estimated to be 4,000,000 acre-feet per year...." Following the Supreme Court decision in *Arizona v. California* (1963), MWD took steps to increase its entitlement to project water and the minimum project yield was increased to 4,230,000 acre-feet.

The term "minimum project yield" means the total net dependable supply, with deficiencies in some years, to be made available to the turnouts of the water service contractors. The gross yield of the project is larger, as it includes the water used for recreation, fish and wildlife and water lost in the project operations, such as seepage and evaporation from the project facilities. The gross yield is the total amount that must be provided by the conservation facilities.

The water supply contracts provide that the DWR will estimate yield capabilities of conservation facilities based upon coordinated operation studies. Contracts require the DWR to report at five-year intervals on its ability to meet future demands for project water and on its plans for constructing future conservation facilities. The Burns-Porter Act also made provision for constructing water conservation facilities to supplement the minimum project yield.

The DWR estimates that the firm supply exportable from the Delta with existing facilities (excluding Peripheral Canal) of the SWP and the CVP and upstream depletions expected in 1980, is about 5.8 million acre-feet annually. The SWP share is estimated by the DWR to be 2.4 million acre-feet of this amount. These estimates are based on long-term hydrologic records, including a repeat of the 1928-34 drought, but not the more severe 1976-77 drought years, which may not be controlling if they continue to be isolated among wet and normal years. The estimates are also based on the criteria set by the SWRCB in D-1485. These criteria include some relaxation in dry and critical years.

In the development of the water contracting program for the SWP, recognition was given to the capability of the Project to deliver water on an annual basis in excess of contractual water entitlements for a given year, and provision was made for sale of this unused entitlement water, defined as "surplus water." This differs from the Class 2 water in the CVP contracts in that it represents unused entitlement and will diminish in quantity as the entitlement deliveries increase, whereas availability of Class 2 water relates to hydrologic conditions in individual years. Provision was also made for sale of additional water available in years of above normal water supply, called "unregulated surplus water". Provision for sale of surplus water was contained in the prototype contract (MWD) negotiated in 1960, and in 1974 was modified to give priority to the use of surplus water for agricultural or ground water replenishment use.

The future quantities of imported water from the SWP should include both entitlement and surplus water as called for in the water contracts. The availability of surplus water has long been considered as a key element in the overall water resource management programs of the agencies in the southern San Joaquin Valley receiving SWP water.

The Kern County Water Agency structured the buildup of Table A (firm entitlement water) in its contract with the State, and similar provisions in water service contracts with its member units, in reliance upon the availability of surplus water from unused entitlements of other contractors during the early years of SWP operation (up to year 1990). The member unit contracts provide that the Agency will deliver a mix of firm and surplus entitlement in the years prior to 1990 with firm entitlements increasing to full contract amounts in 1990, and surplus entitlement decreasing to zero in 1990. The member units thereby pay prices which reflect the melding of the Agency's costs for firm and surplus water in each year of the build-up period.

Based upon these more favorable early year water costs and on the assumption that supplies equal to their maximum entitlements would be available in the early years, the member units of the Kern County Water Agency developed their programs of financing and construction of irrigation distribution systems for delivery of the SWP water to their water users. These systems were largely completed to their ultimate size and service capability under the initial construction programs in anticipation of

delivery of amounts of water equivalent to 1990 contractual maxima. Furthermore, the individual water users based their decisions respecting participation in the programs on the prospect of the more favorable water costs and water availability.

Surplus water will not be available in the future in the same quantities as earlier planned because of higher Delta outflow requirements to be met by the SWP under D-1485 and the absence of the Peripheral Canal, and interpretations of the obligations of the State relative to surplus water provisions of the contracts. Surplus water has a direct relationship to the annual overdraft, as any amount of surplus water not delivered under the program adds that much to the overdraft.

The future import of water to the San Joaquin Valley from the SWP will also be affected by the demand for project water in other areas served by the Project. The annual water entitlements called for in the water service contracts for the San Joaquin Valley and for the total SWP are shown in Table 14.

TABLE 14

TABLE A ENTITLEMENTS TO WATER FROM THE STATE WATER PROJECT

[1,000 acre-feet per year]

Year	San Joaquin Valley	Total SWP Service Area
1979	708	2,022
1980	765	2,231
1981	828	2,427
1982	889	2,618
1983	956	2,817
1984	1,018	3,013
1985	1,079	3,214
1986	1,139	3,415
1987	1,201	3,620
1988	1,259	3,828
1989	1,303	4,030
1990	1,355	4,192
2000	1,355	4,229

It can be seen that the annual entitlements to SWP water have essentially reached the capability of the Project to deliver 2.4 million acre-feet on a firm basis with the presently constructed facilities. The ability of the Project to deliver entitlement water in the future is dependent on the deferral of portions of maximum entitlements by water service contractors in other service areas because of reduced rate of growth, particularly in southern California.

Operation studies made by the DWR and reported in May 1978, showed that, after meeting the requirements being recommended by the SWRCB for D-1485, there would be some potential for intermittent export supply (unregulated surplus water) from the Delta. The average potential for such surplus water was about 80,000 acre-feet per year for 1980 conditions without the Peripheral Canal and about 370,000 acre-feet per year with the Peripheral Canal in operation.

Additional Developable Water Supply

Additional water supply that can be developed in northern California for export out of the Delta for the CVP and SWP should be considered in the context of Coordinated Project Operation. It is first necessary to consider the combined CVP-SWP yield capability from the Delta. This combined yield of about 5.8 million acre-feet is as shown in Table 15.

TABLE 15

ESTIMATED COMBINED CVP-SWP YIELD FROM THE DELTA

Service Area	Annual Yield (1,000 acre-feet)
Central Valley Project	
Delivery to southern San Joaquin Valley	1,966
Additional D-MC Service	1,020
San Felipe Unit	196
Contra Costa Canal	195
State Water Project	2,400
Total	5,777

Potential developments which could increase the yield capability from the Delta are discussed in the following sections of this chapter.

Peripheral Canal

A major constraint on the quantities of water which the CVP and SWP can export from the southern part of the Delta is the need to supply satisfactory water quality at the diversion pumps after meeting required levels of water quality in the western Delta. The drought years of 1976 and 1977 showed that even with a relaxation in Delta water quality criteria by the SWRCB, the levels of diversions at the pumps of the two projects were limited by water quality degradation occurring from the intrusion of salt water from Suisun Bay. For example during 1977, the SWP diverted a total of only 139 thousand acre-feet during the period April 1 — August 31 while releasing 673,000 acre-feet from Oroville Reservoir for Delta inflow during that same period.

Cross Delta facilities have been studied extensively for many years and the Peripheral Canal was determined to be

Photo Courtesy U.S. Bureau of Reclamation.

Permanent set sprinklers in a new vineyard in western San Joaquin Valley provides for efficiently controlled irrigation. Wide spread use of such systems is limited because of cost.

the most efficient facility that will both protect the Delta environment and provide water for export. The amount of increased combined yield for the two projects which could be achieved by construction and operation of the Peripheral Canal, as determined from DWR studies, is about 1.2 million acre-feet per year, of which the DWR estimates as much as 600,000 acre-feet would accrue to the SWP.

The Peripheral Canal was under final design by the DWR and construction had been scheduled to commence in August 1974, but was rescheduled with a one year delay for the preparation of the environmental impact report. Initiation of construction was further delayed when the current State Administration required new studies of Delta alternatives. During 1977, the State Administration concluded that the Peripheral Canal should be constructed and sponsored comprehensive legislation which included its implementation.

This legislation (SB 346, Ayala) provided for construction of the Peripheral Canal subject to certain conditions precedent, which were found to be objectionable to Valley agricultural and urban water interests. These conditions included the execution of agreements with Delta water agencies and with the Secretary of the Interior and Congressional authorization. Senate Bill 346 failed passage in 1978. Plans of the State Administration for proceeding with the Canal are uncertain as is Federal participation. A project feasibility report and environmental impact statement are in preparation by the USBR. Approval by the Secretary of the Interior and the President, and Congressional authorization, would be required for a joint-use facility. The outlook for early Federal authorization is dim. The last USBR project involving the transfer of water to be authorized in California was the San Felipe Unit of the CVP in 1967.

Auburn Dam

Auburn Dam on the American River was authorized in 1965 as part of the Auburn-Folsom South Unit of the CVP. Construction of appurtenances to Auburn Dam and foundation excavation have proceeded since that time. Questions of the seismic safety have been raised regarding the design features of the dam and the USBR recently announced that consideration is being given to the design of a different type of dam than originally proposed. Litigation by environmental groups challenged construction of both the dam and Folsom South Canal in *Natural Resources Defense Council v. Stamm.* Construction on the Canal is still in abeyance.

The annual yield from Auburn Reservoir delivered at the Delta would be about 320,000 acre-feet. This yield, however, with the yield from Folsom Reservoir, would eventually be used in the Folsom South Canal service area in southern Sacramento County and San Joaquin County. Overdraft now is occurring in eastern San Joaquin County with a degradation of ground water quality resulting from intrusion of saline water. Several water districts in eastern San Joaquin County are negotiating to obtain contracts for water deliveries to the area. If Auburn Dam is constructed, however, its yield would increase the CVP capability and would be available for assistance in meeting Delta water quality criteria and for diversion to the San Joaquin Valley until water demands in the Folsom South Canal service area exceed the yield capability of Folsom Reservoir.

New Melones Project

The New Melones Project on the Stanislaus River was authorized for construction by the Corps of Engineers in 1944. It was reauthorized as a large multipurpose project in 1962 with integration into the CVP and operation by the USBR. Water service to an undefined Stanislaus River Basin area was an authorized purpose and such service was to have permanent priority over any diversions from the Basin area.

Construction of New Melones Project was interrupted for more than a year as a result of litigation commencing in 1972 on the adequacy of the EIS in *Environmental Defense Fund v. Armstrong* and a supplementary EIS was prepared. In November 1973, the United States Court of Appeals held that the EIS met the requirements of the National Environmental Policy Act and construction was allowed to resume.

The annual yield of New Melones Reservoir will be about 220,000 acre-feet in addition to the releases for fisheries and water quality control downstream in the San Joaquin River. This yield can all be used in water deficient areas adjacent to the project. Several water districts in San Joaquin and Stanislaus counties are currently attempting to contract for the yield of New Melones. Until the project yield is put to use in the local areas, it will be available in the Delta for export in addition to that from Folsom and Auburn reservoirs. However, the reservoir could not be operated to attain the water yield and power generation while complying with the current restrictions imposed by D-1422. As discussed earlier, this issue is still before the court.

The State Administration has continued to indicate, by public statements and correspondence, a policy of even more restricted filling and operation of New Melones Reservoir than provided in D-1422. Among these is a letter of December 12, 1978, from the Secretary for Resources to the Deputy Under Secretary, Department of the Army, regarding the reservoir filling and the use of the yield of the project. The letter includes the following statement:

> "The conflicts raised by the issues involved in the New Melones issue stem from the demand for unrestricted export of water for commerical use by special interests, and the often conflicting need to preserve and manage resources and natural systems for the use and enjoyment of a broader part of present and future populations."

Sacramento Valley Water Development

There is presently uncommitted water in the Sacramento Valley that can be developed. There is a need for additional flood control and water supply in the Sacramento Valley and several potential multiple purpose water developments are being considered. The more recent reports by the DWR that discuss these potential projects are: "Major Surface Water Development Opportunities in the Sacramento Valley," February 1975; and "Key Elements — SB 346," November 1977.

Several tributary storage projects have been studied, but their feasibilities have not been determined and the yield in new water supply measured at the Delta is uncertain. The export water supply would depend on project staging as the reservoirs would be used to firm intermittent inflows to the Delta. The total yield would not be cumulative of the individual projects.

Cottonwood Creek Project. Cottonwood Creek Project, consisting of two dams on Cottonwood Creek, is authorized for construction by the Corps of Engineers and preconstruction planning was initiated in 1976. The project yield measured in the Delta would be about 170,000 acre-feet per year. This yield could be marketed in the CVP or to the SWP through the Water Supply Act of 1958.

Marysville Dam. Marysville Dam on the Yuba River is an authorized multiple purpose project of the Corps of Engineers. This project is now in the preconstruction planning phase. Because of escalating costs, environmental and other opposition, the construction of this project in the

foreseeable future is doubtful. The new water yield would be about 150,000 acre-feet per year.

Off-Stream Storage. Off-stream storage of water above the Delta and south of the Delta has been studied rather extensively over many years. The concept is similar to that of San Luis Reservoir and requires pumping from the Sacramento River or Delta into a reservoir or reservoirs at times of excess or flood flow and release on a schedule to meet water demands. Power for pumping is required, although some of the energy would be recovered when release was made from the reservoir. The project in the Sacramento Valley with the most potential is probably the Glenn Reservoir. This reservoir would be created by dams on Thomes and Stony Creeks, in Tehama and Glenn counties, with flood waters pumped from the Sacramento River. This project would have a storage capacity of about 9 million acre-feet and provide a yield of about one million acre-feet per year.

Other off-stream storage projects under consideration include Colusa Reservoir in Glenn and Colusa counties, Los Vaqueros Reservoir in Contra Costa County and Los Banos Grandes Reservoir in Merced County. The Department of Water Resources has indicated that a Los Vaqueros Reservoir constructed in conjunction with a Glenn Reservoir would yield an additional 160,000 acre-feet per year. The continuing escalation of power costs (for pumping) will be a major factor in the feasibility of these proposals.

Enlarged Shasta Dam. At the time Shasta Dam was constructed, it was known that additional reservoir storage on the Sacramento River would be required for flood control and water supply. Physically, the only feasible site for major additional storage was at Iron Canyon, near Red Bluff. The Table Mountain Reservoir Project at Iron Canyon was authorized in 1944 for construction by the Corps of Engineers and subsequently deauthorized primarily because urban development had encroached into the reservoir area and because of potential for fishery problems.

To secure the increased storage on the Sacramento River, further investigation was given to Shasta Dam. The potential for raising Shasta Dam has been discussed for several years by Federal and State water planners and was presented in the 1978 USBR report "Enlarging Shasta Lake." Significant quantities of additional yield might be developed depending on the degree of enlargement.

The USBR estimates that an increased yield of 1.4 million acre-feet per year might be attained by increasing the height by 200 feet which would enlarge the reservoir storage from its present 4.5 million acre-feet to 14 million acre-feet. Increased flood control and power generation would also result from such an enlargement. Detailed studies need to be made to determine the project feasibility. Such a project could probably not be constructed before the year 2000 but could assist in meeting the long-range water deficiencies in the San Joaquin Valley.

North Coastal Development

In the preparation of The California Water Plan, consideration was given to the potential for several reservoirs to be constructed on the North Coast rivers and diversion into the Sacramento Valley. Trinity Dam (Clair Engle Lake) has been constructed on the Trinity River by the USBR. Subsequent to the preparation of The California Water Plan, there has been little consideration of projects on most of the North Coastal rivers because of environmental and other problems. Studies on the Eel River, however, were extensively conducted by the DWR, USBR and the Corps of Engineers, prior to the enactment by the Legislature of the Wild and Scenic Rivers legislation in 1972.

The principal projects on the Eel River studied by the State and Federal agencies were: English Ridge on the upper Eel, Dos Rios on the Middle Fork and Yellowjacket on the lower Eel. These projects, independently or in combination, would develop varying amounts of new water yield in addition to flood control, hydroelectric power and recreation. A major transbasin conveyance system would be required to bring water into the Sacramento Valley and the Delta. Several of the Eel River alternatives include additional storage on the Sacramento Valley side of the Coast Range. These projects are not without major engineering and environmental problems which have been identified in some detail by the DWR and Federal agencies in several reports on their investigations.

The yield from developments on the Eel River as measured in the Sacramento-San Joaquin Delta varies, depending on the specific development or combination of developments. An annual yield of one million acre-feet or more is possible. A comparison of the principal alternatives on the Eel River is contained in DWR Bulletin No. 175, "Alternative Eel River Projects and Conveyance Routes," December 1972 (unpublished).

Mid-Valley Canal

The Mid-Valley Canal Project is a conveyance facility proposed for delivery of supplemental water to the area of ground water overdraft in the eastern part of the San Joaquin Valley, from Madera County south to Kern County. This Project has been under study for several years by Federal, State and local interests.

The Canal would head at a point on the California Aqueduct, immediately upstream from Dos Amigos Pumping Plant, and extend southeasterly across the trough of the Valley and continue southward along the east side of the Valley.

Water supplies presently available to Mid-Valley Canal

are erratic and would occur at times of surplus in the Delta. Excess capacity in the California Aqueduct would be utilized from the Delta to the point of diversion to Mid-Valley Canal.

Water supplies delivered through this facility would be integrated with existing conjunctive-use programs and with those programs which would be initiated by newly formed districts or existing districts now without a supplemental water supply. These supplies would be used directly for irrigation in lieu of ground water pumping, when possible, or for artificial recharge. The average annual supply, which could be delivered to the east side through Mid-Valley Canal under present conditions, is estimated to be from 200,000 to 500,000 acre-feet. In the future, the Canal would be utilized to deliver a firm water supply developed by additional conservation works.

Legislation would be required for the Mid-Valley Canal to become a unit of the CVP or SWP. The facility also could be constructed by a local agency or agencies.

CHAPTER VI
GROUND WATER MANAGEMENT

Management of the ground water resources of the southern San Joaquin Valley commenced more than fifty years ago and, with a continued increase in the use of ground water for both irrigated agriculture and urban and industrial needs, has now reached unprecedented levels of magnitude and sophistication. Presented in this chapter is a summary of the evolution of this vast array of management programs and their current status. To enable a better understanding of management of the ground water resource in the southern San Joaquin Valley, there are set forth discussions of the elements of ground water management and a description of selected management programs in California.

What is Ground Water Management?

Ground water management, as commonly understood and practiced in California and other western states, may be defined as a program purposely devised for the utilization of the ground water resources to achieve desired physical or economic objectives. Ground water management in California has, without exception, involved the conjunctive use of surface and ground water resources, wherein, in accordance with locally prevailing physical and economic conditions, water supplies from the two sources are integrated to accomplish the optimum utilization of each.

A ground water management program may include, but does not necessarily, require:

(1) Construction of physical works.
(2) Direct recharge and recovery of ground water.
(3) Adjudication of the rights to use of ground water.
(4) Control of ground water extractions.

It is to be emphasized that ground water management, or the conjunctive use of surface and ground water, does not imply or necessarily require a reduction in the use of ground water. Further, the existence of overdraft in a ground water basin does not indicate the absence of management. To the contrary, numerous well-managed ground water areas suffer overdraft which only indicates an inadequate supply of supplemental surface water to integrate into the management program.

Ground water management does require development of a financial program to obtain revenue to defray program costs including the identification of beneficiaries of the program and a determination of an equitable plan for sharing the costs.

Elements of Ground Water Management

The specific elements of a particular ground water management program reflect individual topographic, geologic and water supply characteristics of the area, cost factors and the management objective of the program beneficiaries.

The basic objective of the management programs undertaken in California is to preserve and maximize the utility of the ground water resource through conjunctive use with available surface water, all with the view of obtaining an adequate water supply of satisfactory quality at the least possible cost. Elements of management described in the following paragraphs are schematically depicted on Plate 5 "Conjunctive Use of Ground Water and Surface Water."

The Surface Water Supply

Sources of surface water supply may include local stream flow, varying from small ephemeral streams producing runoff in direct response to rainfall to the larger rivers having sustained flow from snow melt throughout the year. The larger rivers are now, almost without exception, controlled by multi-purpose dams and reservoirs which provide a more even flow, throughout the year and between years, than under natural conditions. At times, because of conflicting operational criteria between purposes, these reservoirs cannot always be operated to effect rates of release of stored water consistent with the ability of the benefited area to obtain maximum conservation thereof.

Surface water sources in California available to managed ground water areas also include supplies from the major water transfer projects as the SWP, the CVP, the Colorado River Aqueduct, the Los Angeles Aqueduct, the Hetch Hetchy Aqueduct and others. The operational characteristics of these projects and the characteristics of water availability therefrom, differ from each other and from the local stream systems.

The characteristics of occurrence and magnitude of these different surface water supplies in turn affect the characteristics of individual conjunctive-use operations and ground water management programs.

Ground Water Basin Characteristics

The nature of subsurface strata from which ground water is extracted (aquifers), together with the permeability of the surface soils, has a most significant effect on the

concept of a ground water management program in any given area.

Ground water can occur either in an unconfined (free) or confined (artesian or pressure) state, as well as in some intermediate stage of confinement. In the unconfined state, the aquifers and the water therein may be likened to a surface reservoir wherein the elevation of the water surface reflects the amount of water in storage, and in such areas water can usually be readily recharged directly from the surface. During "wet" years of above-average availability of surface recharge, the reservoir gains in storage and the water table rises. During "dry" years of less than average recharge, ground water storage may be depleted by pumping and the water table declines. This similarity between surface and ground water reservoirs was vividly shown during the "dry" years of 1976 and 1977, which were followed by the "wet" year of 1978, and is depicted graphically on Figure 2.

Confined ground water, on the other hand, may be likened to a pipeline conduit supplied by a storage reservoir. The elevation of the ground water level in wells penetrating confined aquifers reflects the pressure on the aquifer which is usually fed from the unconfined ground water body or "reservoir". Fluctuations of water levels in wells penetrating confined aquifers reflect changes in storage in the unconfined ground water body and also changes in pressure caused by the operation or cessation of the pumping of wells utilizing the aquifer. Fully confined aquifers cannot be replenished directly from the surface. Continued pumping of a confined aquifer in excess of recharge can reduce the pressure level below the elevation of the confining stratum so that ground water remaining therein exists in an unconfined state.

Fully confined or unconfined aquifers generally do not exist in nature as the confining clay layers are not continuous. The individual local characteristics must be accommodated in management programs. The occurrence of ground water, whether confined or unconfined, together with the permeability of the overlying soils, act to dictate the concept of a ground water management program and, particularly, the manner in which the ground water supply is recharged.

Compaction of water-bearing deposits in certain areas of the southern San Joaquin Valley ground water basin, and accompanying land subsidence, are related to a reduction in artesian pressure in the deposits resulting from confined ground water being extracted faster than it is being replenished. Compaction of water-bearing alluvial deposits is a continuing natural process that has been occurring for millions of years. Land subsidence in the southern San Joaquin Valley has been known since the middle 1930's and reflects an acceleration of natural compaction.

Alluvial deposits which comprise the ground water basin can be broadly separated into coarse-grained materials, i.e., sands and gravels (aquifers) and fine-grained materials, i.e., clays and silts. Aquifers release water easily to wells and are readily recharged. Silts and clays, on the other hand, have relatively large pore spaces which are filled with water, but the low permeability of these fine-grained materials prevents water from being easily removed or replaced. When ground water levels are lowered, the buoyant support for both fine-grained and coarse-grained materials is removed and the effective overburden load increases. In response to the increased load, clay-size particles move closer together, the pore space is reduced, water is "squeezed" out and the clay is compacted. Sands and gravels exhibit a more stable grain structure which does not change appreciably in response to the increased loading which accompanies a lowering of ground water levels.

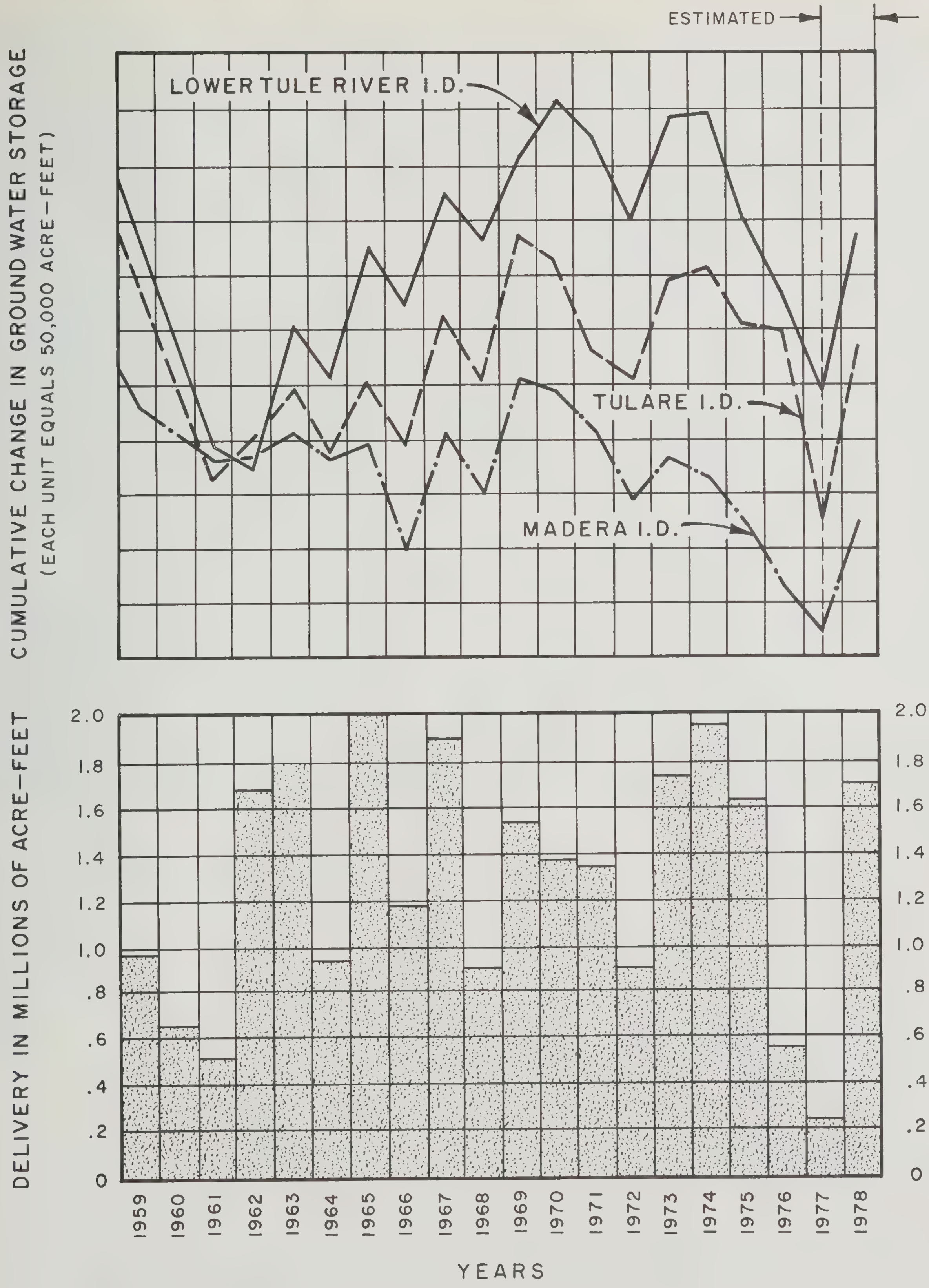
Estimates prepared by the USGS indicate that over 15 million acre-feet of extracted ground water had been obtained from compacted clays by 1970. This water of compaction is considered a "one-time" resource which would otherwise have had to be imported to the Valley or removed by pumping from greater depth. Water removed from the clays could not have been recovered without the compaction which accompanied a lowering of ground water levels. No loss in usable ground water storage occurred because the clays are not replenishable, either before or after compaction. A relatively small amount of compaction of aquifer materials (sands and gravels) may have occurred, but the reduction in usable ground water storage capacity is considered negligible.

Although subsidence has resulted in damage to wells and many surface facilities, requiring expenditure of substantial funds for repair or replacement, not all of the effects can be considered adverse. The deposits of the ground water basin are largely "preconsolidated" to their historic low water levels and, with the availability of full allocations of supplemental water, the basin can be managed and ground water storage cycled to the historic low water levels without the threat of serious additional subsidence. A benefit has also been provided, in that the depths to water and attendant pumping lifts have increased more slowly than if comparable volumes of water had been withdrawn from a less compressible aquifer system.

Recharge Methods

Recharge of ground water occurs naturally and through deliberate, controlled means (artificial). Natural recharge occurs (1) by percolation from rivers and streams in absorptive areas, (2) by direct precipitation on the ground water basin and (3) by subsurface lateral movement of ground water from portions of the basin where water levels are higher and from hills and mountains adjacent to a basin. In the southern San Joaquin Valley, the limited amount of direct precipitation on absorptive areas generally does not contribute significantly to ground water recharge.

Artificical recharge includes the intentional percolation of surface water in natural channels, basins, pits or ponds constructed for that purpose, unlined constructed channels, off-season irrigation of cultivated lands, injection wells, and incidental percolation from unlined channels and canals



NOTE: ADAPTED FROM U.S. BUREAU OF RECLAMATION DATA.

RELATIONSHIP BETWEEN ANNUAL MAGNITUDE OF DELIVERY FROM MILLERTON LAKE AND CHANGES IN GROUND WATER STORAGE IN SELECTED MANAGED GROUND WATER AREAS

utilized in the conveyance of water for surface use as well as percolation of irrigation water not consumed by evapotranspiration of cropped lands. Percolation of waste effluent to ground water from municipal facilities can be either intentional or incidental to the disposal.

Benefits of recharge, or equivalent recharge, can indirectly be achieved when surface water is used in lieu of ground water pumping and the reduced pumping rate is less than natural and artificial recharge rates.

Basins and Ponds. These facilities are utilized extensively in the southern San Joaquin Valley and in southern California on alluvial fans found along major stream systems discharging from the mountains wherein porous materials exist from the surface to the ground water table. They are ideally located on nondevelopable lands within overflow areas of streams, which can be acquired at minimum cost, although a substantial amount of otherwise irrigable farm land has been dedicated to this purpose in the southern San Joaquin Valley.

Unlined Channels. Throughout the east side of the San Joaquin Valley there exists a complex system of unlined canals and ditches used to divert water from various streams to irrigated lands. Seepage from these unlined facilities occurs incidentally to normal operations. Unlined facilities, together with the natural stream and river channels, are utilized intentionally for recharge during winter and spring months of years of above-average runoff. Natural channels are extensively utilized in other parts of California for percolation of both local and imported water. Temporary low dams are frequently constructed each year to increase the area and depths of water during low-flow periods.

Off-Season Irrigation of Cultivated Lands. In years when abundant surface water supplies are available, recharge is achieved by delivering water to irrigated lands prior to initial planting. Such practice accomplishes the dual purpose of water conservation and preirrigation for the ensuing crop.

Injection Wells. Injection wells have been utilized in certain areas of California for direct artificial recharge. They have been used for many years along the coastline in the West Coast Basin of southern California to provide a mound of fresh water to prevent landward movement of sea water. Limiting factors in the widespread use of wells for recharge are costs and the rather minimal rates of injection that can be achieved.

Conjunctive Use of Surface and Ground Water

There are several alternative means of conjunctively using surface and ground water depending on facilities, ground water basin characteristics, amounts and quality of the supplies, costs, administrative arrangements and other factors. The more significant aspects of conjunctive use are described in the following paragraphs and some are shown graphically on Plate 5.

Surface Delivery in Lieu of Ground Water Pumping. This method of achieving ground water recovery is the most extensive of the management mechanisms employed in California. Employment of this method requires substantial capital investment for construction of surface delivery facilities. In areas of confined ground water and those having surface soils of low permeability, it is used out of necessity. In absorptive areas, this method is employed for economic reasons when it is found to be less costly to serve surface water directly to the user rather than to percolate it and subsequently recover it through wells.

Transfers to Neighboring Areas Sharing a Common Ground Water Supply. Transfers of water are a common practice in years of abundant water supply, particularly in the service areas of the Kings River and Friant-Kern Canal of the southern San Joaquin Valley. A downstream area, usually a public water district, will sell or otherwise transfer a portion of its right, or contractual entitlement to a surface water supply, to an upstream, adjacent district having a greater recharge capability. The purchasing district will benefit directly through delivery for irrigation or by percolating the water to increase the elevation of the water table. The seller of the supply will also benefit by an increase in elevation of its ground water levels (either confined or unconfined). Both districts will benefit through the conservation, within a common ground water area, of water that otherwise would have wasted to the ocean or been lost to that area.

Exchanges. Water exchanges as a recharge and management tool have been extensively utilized in the southern San Joaquin Valley because of wide variations from year to year in the availability of surface water, differences in recharge capability and existence of facilities to deliver surface water. Such exchanges usually involve two or more public agencies having different sources of surface water and different recharge and surface delivery capabilities. As an example, District A delivers its water to District B at a time when District A cannot either directly use the supply or percolate it to the underground and when such capability exists within District B. District B subsequently repays District A with an equivalent amount of water or an amount of water of equivalent value.

Control of Ground Water Extractions

Ground water management programs may include extraction of ground water through private wells only, both private and public wells or, in some instances, public wells only. Public wells owned by the management entity are often used in connection with a recharge program of that entity. The recent California Supreme Court decision in the case of *Los Angeles v. San Fernando*, has clarified the law with respect to the rights to recover water intentionally stored in the underground by a public entity.

Management programs often include control of ground water extractions to a desired limit, such as the safe yield of

Photo Courtesy U.S. Bureau of Reclamation.

Friant Dam on the San Joaquin River stores water in Millerton Lake for release into the Friant-Kern Canal on the right and Madera Canal on the left, furnishing supplemental water for conjunctive use by east-side water management entities from north Madera County to South Kern County.

the basin. This has been achieved in two ways in California: (1) by adjudication of rights to use ground water and by reduction and subsequent control of ground water extractions; and (2) by economic inducement wherein, through establishment of an appropriate pricing and taxation or assessment structure, less costly surface water is utilized on a voluntary basis in lieu of pumping ground water. It is important to note that, although the objective of the management program is achieved in both instances, the mechanisms by which this objective is achieved are entirely different, being mandatory in one instance and voluntary in the other. From a review of adjudicated ground water basins, it can be noted that in no instance has a reduction in ground water extractions, resulting from an adjudication procedure, been put into effect in the absence of an adequate supply of supplemental water to compensate for the reduction in ground water use. In other words, there was always an alternative water supply available to the pumpers.

Institutional Considerations

Implementation of a program of ground water management has usually required the existence of a public body or bodies endowed with powers to sell water, levy taxes or assessments, acquire land, obtain water rights, finance and construct facilities, recharge and recover ground water and otherwise carry out all elements of a management program as described. In certain instances, mutual water companies and other private entities have effectively instituted management programs.

Financial and Economic Considerations

Each management program has a financial element to generate revenue to purchase water for recharge, to adjust relative costs of surface and ground water, to operate facilities and to repay costs of any surface delivery facilities

TABLE 16

GROUND WATER BASINS IN WHICH OVERDRAFT CORRECTION DEPENDS ON IMPORTED WATER

County	Basin	Operating Agency	Import System	Initial Import
Alameda	Alameda Bayside	East Bay MUD, City of Hayward	Mokelumne Aq. Hetch Hetchy Aq.	1930 1950
Alameda	Niles Cone	Alameda Co. WD	South Bay Aqueduct (State Water Project)	1962
Alameda	Livermore Valley (Central Area)	Alameda Co. FC & WCD, Zone 7	South Bay Aqueduct (State Water Project)	1962
Alameda and Contra Costa	Livermore Valley (Pleasanton Area)	City of San Francisco	Hetch Hetchy Aq. (Substitution)	1934
Contra Costa	Walnut Creek Concord Area	Contra Costa Co. WD	Contra Costa Canal	1941
Fresno, Kern, Kings, Madera, Tulare	Southern San Joaquin	Many water agencies	California Aqueduct Delta-Mendota Canal Cross Valley Canal Mid-Valley Canal Other	1968 1951 1975 ? ?
Los Angeles	Raymond	City of Pasadena, et al	Colorado River Aq. California Aqueduct	1944 1972
Los Angeles	West Coast	Central and West Basin WRD	Los Angeles Aq. Colorado River Aq. California Aqueduct	1935 1948 1972
Los Angeles	Central	Central and West Basin WRD	Los Angeles Aq. Colorado River Aq. California Aqueduct	1935 1954 1972
Los Angeles	Main San Gabriel	Upper San Gabriel Valley MWD	Colorado River Aq. California Aqueduct	1964 1974
Los Angeles	San Fernando	City of Los Angeles	Los Angeles Aq. Colorado River Aq. California Aqueduct	1915 1941 1972
Orange	Costal Plain- Orange County	Orange Co. WD	Colorado River Aq. California Aqueduct	1949 1973
San Bernardino	Bunker Hill	San Bernardino Valley MWD	California Aqueduct	1972
San Bernardino and Riverside	Chino-Riverside Area	Chino Basin MWD and Western MWD	Colorado River Aq. California Aqueduct	1951 1973
San Joaquin	Central San Joaquin	Stockton-East WD No. San Joaquin WCD	Folsom South Canal	?
Santa Clara	Santa Clara Valley	Santa Clara Valley WD	South Bay Aqueduct (State Water Project) San Felipe Project	1965 1986
Solano	Solano	Solano Co. FC & WCD	Putah South Canal	1959
Ventura	Oxnard Plain	Calleguas MWD Ventura Co. FCD	Colorado River Aq. California Aqueduct California Aqueduct	1968 1972 ?
Yolo	Davis-Woodland Area	Yolo Co. FC & WCD	Tehama-Colusa Canal plus extension	1980 ?

Abbreviations:

FCD — Flood Control District
MUD — Municipal Utility District
MWD — Metropolitan Water District
WCD — Water Conservation District
WD — Water District
WRD — Water Replenishment District

involved in the conjunctive operation. Consideration must be given to identification of beneficiaries of the program and to the equitable collection of monies from these beneficiaries through taxes or assessments and revenues from water sales to defray the foregoing costs. Financial elements vary considerably among management programs depending on the individual characteristics of the area, the source or sources of the surface water supplies and the nature of the management program itself. These programs, however, have a common purpose in obtaining required revenue from beneficiaries of the program in accordance with benefits received.

What is Overdraft?

Overdraft is commonly defined as the annual net extraction of ground water in excess of the safe yield of the ground water basin. Safe yield of the ground water basin is the amount of water which can be withdrawn annually without producing an undesired result. Both terms are used in the context of a long-term period of average water supply which would include both "wet" and "dry" phases of the climatic cycle. The terms are often misused and confusion develops during a dry year or series of dry years when ground water in storage is reduced and overdraft is suggested. As shown on Figure 2, ground water in storage in California is expected to be reduced in dry years and restored in wet years, in exactly the same manner that a surface reservoir is operated. The imbalance between water supply and use in a given year or short period of years reflected by a lowering of ground water levels is not an indication of overdraft.

The terms are also often misunderstood with respect to the physical and economic implications of each. In particular, overdraft is a much maligned term. The following is quoted from "Economics and Public Policy in Water Resources Development" 1964 (Wells A. Hutchins, U. S. Department of Agriculture):

> "Overdraft is not bad per se. Great values have been built up in some areas in which individual pumping has been unrestricted; some such communities can now afford to pay for imported water supplies with which to sustain the economy thus attained. And in planned utilization of ground water reservoirs, referred to in a following section, overdrafts will be a part of the program. But protracted overdraft conditions in many areas have had adverse effects. These include continued depletion of the reservoir, with increasing pumping costs and threatened destruction of the water supply, contamination of the water, salt water intrusion and land subsidence."

Such has been the case throughout California and is continuing today. Areas in the San Francisco Bay counties, in the Central Valley, in southern California and in coastal valleys, overdrafted ground water to a point where it was necessary to take action to reduce pumping.

Role of Overdraft in California's Development

The practice of overdrafting a ground water basin has been described as "the tragedy of the pool" since it is considered by some to be analagous to "The Tragedy of the Commons" described by Hardin in *Science*, 1968. The commons case, which involved unrestrained individual use of community-owned pasture to such an extent that its grazing value was destroyed, was an analogy in a population paper by W. F. Lloyd in the early 19th century. His comparison was related to a situation with limited resources. Conclusions regarding water resources, which are not limiting in California, depend on the scope or geographic limits of the pool and the water resources.

If the geographic area is defined to preclude any likely outside supplemental supplies, then use in excess of supply will lead to problems and eventual curtailment. If, however, water supplies of California are considered to be available for all areas of the State, as envisioned in The California Water Plan, ground water overdraft can be an effective means of building an economy which can afford to share in the more expensive water from other portions of the State pool.

This type of staged development and growth has occurred throughout most of California. Those developed areas which had access to stored ground water have utilized it in an acceptable manner. Instead of isolated tragedies throughout California, initial overdrafting has been corrected by importing water and local economies have grown instead of stagnating.

In considering current and future ground water management, it is appropriate to review past practices which provide much of the legal, administrative and financial basis for water rights and project construction and operation. Some of the regions which have overdrafted ground water before supplemental water was brought in are described in the following sections. The locations and agencies involved in the areas where imported water is essential to correcting an overdraft situation are summarized in Table 16.

Alameda Bayside and Niles Cone, Alameda County

Early development of urban areas in Alameda County adjacent to San Francisco Bay centered around Oakland and Berkeley. The area south of Oakland, which was in agriculture, now is largely occupied by urban development. In about 1893, the Oakland Water Company obtained water from artesian wells near the present Union City and pumped it about 20 miles north to Oakland. Local streams were developed with reservoirs and when these sources were foreseen to be inadequate, the East Bay Municipal Utility

District turned to the Mokelumne River in the Central Valley and began importing water in 1930.

Irrigated agriculture and communities outside of East Bay MUD pumped ground water from aquifers adjacent to and beneath south San Francisco Bay. The rate of extraction exceeded the recharge and serious salt water intrusion into the aquifers developed throughout much of the Bay plain in southwestern Alameda County. Limited relief from ground water pumping was provided by water released into Alameda Creek from facilities of the City of San Francisco and by direct service by the City to the City of Hayward. Full control of salt water intrusion and adequate ground water management of the Niles Cone area was made possible by completion of the South Bay Aqueduct of the State Water Project and water service to the Alameda County Water District beginning in June 1962.

San Francisco

Water supply for the initial community of San Francisco was ground water from springs followed by development of local creeks. In the 1860's and 1870's, development was undertaken in the larger watersheds in what is now San Mateo County. It was also recognized about that time, that water resources of the Peninsula would not continue to be adequate and attention was directed across San Francisco Bay to the Alameda Creek watershed. This system included Calaveras Dam and ground water development in Sunol Valley and in Livermore Valley. A dam was constructed on bedrock at the lower end of Sunol Valley and the entire ground water flow through upstream porous gravels was thereby controlled. About 100 wells were drilled into gravels in the western part of Livermore Valley near Pleasanton.

The City has rights to extract up to 15 million gallons daily (15,700 acre-feet annually) from the Pleasanton well field, although the safe yield is estimated to be about six million gallons per day (6,700 acre-feet annually). During the drought in the early 1930's, prior to obtaining water from the Tuolumne River, extensive pumping was undertaken and water levels in wells fell over 100 feet in three years. Water levels recovered after pumping was curtailed. However, when the aquifer was again pumped heavily in the late 1940's, there was a 90-foot drop in a 15-month period. Operation of the Pleasanton well field has provided a water reserve for the City of San Francisco.

The main supply for the City of San Francisco is obtained from the Tuolumne River in the Sierra Nevada and delivered across the Central Valley through the Hetch Hetchy Aqueduct. The City of San Francisco now takes approximately 250,000 acre-feet per year from the Central Valley watershed, in addition to supplies from San Mateo and Alameda counties, and serves water surplus to its needs throughout San Mateo County and portions of Santa Clara County.

Livermore Valley, Alameda County

Livermore Valley, which had about 8,000 irrigated acres and a few thousand people in Livermore and Pleasanton in 1951, experienced rapid growth and increases in water use as population spilled over from the East Bay cities. All water was obtained from the ground water basin and extractions soon exceeded recharge during the period of rapid growth beginning in the early 1950's. The South Bay Aqueduct of the SWP, which was urgently needed for the Bayside Area of Alameda County and for Santa Clara Valley, prevented serious overdraft problems in Livermore Valley. Zone 7 of the Alameda County Flood Control and Water Conservation District was the first area to receive water from the SWP beginning in 1962.

Central Contra Costa County

The area south of the San Joaquin River and Suisun Bay in Contra Costa County was developed early in California's history. Soils and climate of the Ygnacio and Clayton valleys, where Walnut Creek and Concord developed, were well suited to agriculture.

Extensive industrial growth took place along the waterfront and water needs of this growth soon exceeded local resources. The situation was recognized in the State Water Plan submitted to the Legislature in 1931. It was reported that both industry and agriculture relied heavily on ground water.

Wells developed to supply fresh water for industrial needs turned salty. There was an urgent need for an adequate and dependable fresh water supply to serve the industries. There were 18,000 acres of cultivated lands in the Ygnacio and Clayton valleys near Concord and Walnut Creek, of which only about 3,500 acres were under irrigation from underground water supplies. The irrigation draft, combined with the municipal and industrial use of ground water in the valleys, was 50 percent greater than the average annual natural replenishment from tributary streams. The Contra Costa Canal, which was the first operating facility of the CVP, was completed in 1941 to alleviate this serious overdraft and meet expanding needs for water.

Southern California

There are eight well-defined ground water basins in the lower watersheds of the Los Angeles, San Gabriel and Santa Ana rivers which have provided most of the water supplies for agriculture and subsequent development of a major metropolitan area of the world. Overdraft at some stage of development was common to each of them. The availability of supplemental imported water prior to development of individualized management programs was also common to each of them. The basins are:

Basin	Watershed	County
Raymond	San Gabriel River	Los Angeles
West Coast	San Gabriel River	Los Angeles
Central	San Gabriel River	Los Angeles
Main San Gabriel	San Gabriel River	Los Angeles
San Fernando	Los Angeles River	Los Angeles
Coastal Plain-Orange Co.	Santa Ana River	Orange
Bunker Hill	Santa Ana River	San Bernardino
Chino	Santa Ana River	San Bernardino & Riverside

Each of these basins is topographically and/or geologically distinct and for the most part can be managed quite independently of its neighboring basin. The impetus for management was created by a serious problem in each case. The coastal basins, West Coast and Coastal Plain — Orange County, experienced sea water intrusion and the threat of irreparable damage. Inland basins were faced with potential dewatering of aquifers, particularly along the fringe areas, as water levels fell. Some were faced with loss of recharge from upstream areas and the need for litigation to secure their water rights and supply. Deteriorating water quality, due to reuse and waste discharge, was also a problem in the Santa Ana River watershed.

The availability of supplemental imported water to be used in lieu of ground water or to increase the amount of recharge was the key element which made it practical to develop management plans. The Los Angeles Aqueduct from the Owens Valley, the Colorado River Aqueduct from the Colorado River and the California Aqueduct from the Sacramento-San Joaquin Delta were financially feasible because there was an established and expanding economy which had relied in some degree on overdraft. The manner by which imported water was conjunctively used with ground water and the financial and institutional arrangements were individually tailored for each basin. A summary of the key elements of these management plans is presented in a subsequent section.

Central San Joaquin County

The central area of San Joaquin County east of the Delta, including the City of Stockton, relies mainly on ground water. However, some supplemental water for Stockton is obtained from the Calaveras River and water for some irrigated lands around Lodi is obtained from the Mokelumne River. Ground water levels in this area have continued to fall, in some cases for over 50 years. Supplemental water has been expected from the Folsom South Canal since 1957, when The California Water Plan was submitted to the Legislature. Congress authorized the Canal in 1965 and, although construction was started, work was halted in 1974 four miles north of San Joaquin County by environmental challenges. Some supplemental water might be obtained from the completed New Melones Project if administrative and legal issues are resolved. Until supplemental water is available, present irrigation, domestic and industrial needs will require overdrafting the ground water resources. Water levels will continue to fall up to two feet per year and brackish saline water will continue to migrate from beneath the Delta into fresh ground water aquifers underlying the City of Stockton.

Santa Clara Valley

Intensive development of surface water supplies and the conjunctive use of these supplies with ground water in Santa Clara Valley has received widespread publicity and acclaim throughout California and the United States. Locally-sponsored and managed efforts, dating back into the last century, improved ground water conditions until a rapid increase in water use took place during and after World War II. Completion of Anderson and Austrian dams in the early 1950's provided some relief from falling water levels, but demand soon again exceeded supply. Recovery of ground water levels was achieved by delivery of water from South Bay Aqueduct of the SWP beginning in June 1965. The imported supply from this source will not continue to be adequate to prevent recurrence of overdraft and the Santa Clara Valley Water District has contracted with the USBR for additional supplies through facilities of the San Felipe Division of the CVP. Although the ground water resource was heavily overdrawn during some periods, at no time were reductions imposed on the use of ground water.

Solano County

Irrigated agriculture and farm communities in Solano County relied entirely on ground water prior to completion of the Federal Solano Project. Most irrigated land was in the area between Putah Creek and Vacaville. In the Definite Plan Report for the Project, the USBR concluded that overdraft prevailed and that the rate of net ground water use prior to construction of the Project reached 177 percent of the average annual recharge during the 1924-49 period. The manifestation of the overdraft was a ground water depression centered around Dixon which was increasing in size and depth before Project water was delivered through the Putah South Canal. Subsequently, water levels rose as surface water replaced ground water extractions and recharge was increased from deep percolation of a portion of the surface irrigation supply.

Yolo County

Yolo County obtains its water supplies from the Sacramento River, Cache and Putah creeks, which drain the Coast Range lying to the west, and from ground water. The Sacramento River and return drainage systems supply about 35 percent of the demand. In the northern portion of the County, in the vicinity of Dunnigan, supplemental water will be provided by the Tehama-Colusa Canal when it is completed. However, in the area farther south,

generally around Zamora, Woodland and Davis, where there has been rapid urban expanison associated with the University of California, ground water use now exceeds safe yield. In 1967, Congress authorized inclusion of capacity in the Tehama-Colusa Canal for subsequent extension through Yolo County and into Solano County. However, authorization for this extension has not been given. The University has a contract with the Solano County Flood Control and Water Conservation District for delivery of 4,000 acre-feet of water per year from the Solano Project. However, ground water use still exceeds safe yield and the area must continue to rely on the overdrafted ground water source.

Concepts of Management in Southern California Areas

The eight basins on the Coastal Plain of southern California, previously discussed, have well recognized ground water management programs. Management concepts which were developed for each specific basin are not as generally well known. There are distinct differences between southern California ground water conditions and those of the southern San Joaquin Valley and a brief review of the southern California experience can aid in considering the Valley situation.

No attempt is made herein to summarize the southern California programs in detail. They are complex and have been documented in depth elsewhere. With the exception of the Bunker Hill and Chino basins, a complete summary is presented in "Inventory and Summary of Ground Water Management Programs in Southern California and in Tehachapi-Cummings County Water District (Kern County)" prepared by Martin E. Whelan, Esq., and presented as an attachment to the comments of the Southern California Water Conference to the Governor's Commission to Review Water Rights Law, in Los Angeles, August 12, 1978.

These southern basins, unlike the ground water units of the San Joaquin Valley, are well-defined topographically and geologically. Aquifers in coastal basins were threatened with sea water intrusion and, in parts of the interior basins, continued pumping without control would have resulted in the deprivation of certain overlying users of a supply in the basin. With the exception of basins on the Santa Ana River, the Bunker Hill Basin, and the Coastal Plain of Orange County, rights to the use of ground water were adjudicated. The rights to flow of the River and to ground water between certain of the basins were adjudicated. However, in the Main San Gabriel Basin, ground water rights were adjudicated for purposes of defining allocation of basin management costs. In all basins, except Bunker Hill, Orange County and the Main San Gabriel, the amount of pumping has been controlled. In the Chino Basin, individual overlying agricultural pumpers were not limited as to amount, but a share of the estimated safe yield was specified for the entire group of agricultural pumpers. If total pumpage exceeds the group allocation, they are assessed to pay for the cost of importing a like amount of water.

In each basin, there is a "watermaster" to administer the program and the responsibility of the watermaster varies among the basins. The DWR has this role in West Coast, Central and Raymond basins and local agencies or committees act in other cases. In some cases, advisory committees with voting rights were established.

Objectives of the management programs in each of the basins, and of the adjudications, where they were instituted, were to preserve and enhance the utility of the basins as an integral part of the water supply of the area. These basins have been operated conjunctively with imported water, i.e., from the Colorado River, SWP and Owens River. In no basin was an adjudication undertaken, pumping reduced or a management program implemented without an adequate supply of supplemental water. Rather, any reduction in pumping was offset by the use of the imported water supply.

Each program has incorporated therein a financial plan to equitably distribute costs of supplemental water. In the Main San Gabriel and Chino basins, charges for ground water use in excess of the adjudicated pumping right are levied as a replacement water assessment to enable purchase of replenishment water. Similarly, in Orange County there is no restriction on pumping, however, a replenishment assessment or pump tax is levied on all ground water extractions for the purpose of purchasing supplemental replenishment water.

In all cases, "physical solutions" were developed in order to most economically provide water service to program beneficiaries through some form of conjunctive use of surface and ground water supplies.

Table 17 presents a summary of the elements of the management programs in the eight basins.

Evolution of Water Resource Management in the Southern San Joaquin Valley

Management of water resources in the southern San Joaquin Valley involves an area in excess of four million acres, the annual utilization of more than 11 million acre-feet of water, a population of 1.2 million and 63 management entities, for the most part public water districts. The managed situation now established is complex, both physically and institutionally, and its achievement required the concerted efforts of literally thousands of landowners, engineers and attorneys in both the public and private sector over a period of more than fifty years. Management programs have been initiated and carried out locally, supplemented by transfers of water by the State and Federal Governments. The accomplishments of these programs have brought a cornucopia of wealth to California as evidenced by the vast agricultural economy.

The success of these programs was never better demonstrated than during the drought years of 1976 and

1977. Through timely exchanges extending the length of the San Joaquin Valley and into southern California, an economic disaster was averted. Participating in southern California were The Metropolitan Water District of Southern California, Desert Water Agency, San Bernardino Valley Municipal Water District and Coachella Valley County Water District.

Early irrigation development of the Valley commenced in the mid-19th century with diversions from the major east-side snowfed streams. Extensive canal systems were constructed to move water to lands remote from stream channels. Early extractions of ground water were from dug wells. Soon after the turn of the century, the invention of the deep well turbine gave substantial impetus to the use of ground water and it was not long before recognition was given to the conjunctive use of surface and ground water supplies.

The Wright Act of 1887, providing for the creation of irrigation districts, established the first public institutional mechanism by which groups of farmers could band together to collectively carry out water development programs which could not be accomplished individually.

Bulletin No. 11 of the Divisions of Engineering and Irrigation and of Water Rights, entitled "Ground Water Resources of the Southern San Joaquin Valley" by S. T. Harding, was published in 1927, and provides detailed analyses of the use of ground water throughout the southern San Joaquin Valley. At that time, of some 1,370,000 acres under irrigation in the area, 800,000 acres secured all or part of their water supply by pumping from wells. About 400,000 acres were supplied entirely from wells.

During the 1920's, it was recognized that the ever increasing draft on ground water was causing a recession in the water table and that recharge from natural channels was insufficient to compensate for this draft. It became apparent that artificial recharge of flood waters, as well as regulation and redistribution of the surface water supplies available on the east side of the San Joaquin Valley, would have to be undertaken.

Bulletin No. 25 of the Division of Water Resources, "Report to Legislature of 1931 on State Water Plan - 1930", presented a program for the first comprehensive development of the water resources of California and, in particular, the Central Valley. Outlined therein was the program to be known as the Central Valley Project, much of which was later constructed by the USBR. The plan of development outlined in Bulletin No. 25 and its supporting document, Bulletin No. 29 "San Joaquin River Basin", proposed, among other features, construction of Friant Dam and Reservoir on the San Joaquin River and the Madera and Friant-Kern canals and the conjunctive operation of Friant Reservoir (now Millerton Lake) with the east-side ground water units.

Recognition was given to the extensive absorptive areas existing on alluvial fans of the east-side stream systems and

TABLE 17
ELEMENTS OF GROUND WATER MANAGEMENT PROGRAMS IN BASINS OF SOUTHERN CALIFORNIA

Basin	Individual Rights to Pump Adjudicated	Amount of Pumpage Limited	Tax or Assessment on Pumping	Direct Recharge By Management Entity	Equivalent Recharge By Surface Delivery In Lieu of Pumping
Raymond	Yes	Yes	No	No	Yes
San Fernando	Yes (a)	Yes (a)	No	Yes	Yes
Central	Yes	Yes	Yes	Yes	Yes
West Coast	Yes	Yes	Yes	Yes	Yes
Main San Gabriel	Yes (b)	No	Yes	Yes	Yes
Orange County	No	No	Yes	Yes	Yes
Bunker Hill	No (c)	No	No	Yes	Yes
Chino	No (d)	No	Yes	Yes	Yes

(a) Adjudicated rights granted to the City of Los Angeles for local safe yield and all pumpers, including the City, allowed to recapture imported water reaching the ground water supplies.

(b) Adjudication of individual rights as a percentage of the operating safe yield.

(c) No adjudication of individual pumping rights for overlying uses, but exporter rights are individually adjudicated.

(d) No adjudication of individual agricultural pumping rights but industries and cities' rights are individually fixed as a percentage of the operating safe yield.

of the ability of these areas to receive and percolate surplus waters from the San Joaquin River. Water rights along the San Joaquin River, which would be impaired by upstream diversions at Friant Dam, were to be satisfied by releases from a proposed west-side canal (Delta-Mendota) diverting surplus water from the Delta supplemented by regulated releases from Shasta Dam and Reservoir on the Sacramento River. This was the first major "exchange" of water implemented in connection with water resources management in the Valley.

The significant part of this plan, with respect to ground water management, was that only 400,000 acre-feet of storage capacity was to be included in Friant Reservoir, which was recognized as being insufficient to provide long-term carry over of flood waters into dry periods. Rather, it was proposed that absorptive areas would be provided with an "average" supply sufficient to overcome overdraft and underground reservoirs in such areas would be utilized to provide "carry-over" storage. Thus, Friant Reservoir would be operated conjunctively with east-side ground water storage, and would provide a firm water supply where needed and a supply of variable magnitude in absorptive areas overlying usable ground water storage.

This plan with some modifications was implemented by the USBR commencing in the 1930's. The last major distribution unit was completed by the Arvin-Edison Water Storage District and went into operation in 1966.

The USBR has entered into contracts with 26 public entities, from Madera County on the north to southern Kern County on the south, and water was first served in 1951. As originally envisioned, Millerton Lake is operated conjunctively under terms of these contracts. Two classes of water, 1 and 2, are sold under the contracts, with Class 1 water intended to be a firm supply with minimum deficiencies, and Class 2 water, the variable supply. Conjunctive operation of Millerton Lake with ground water storage in the Friant-Kern and Madera canals service areas is depicted graphically on Figure 3. Annual surface water deliveries have varied from a maximum of about 2.2 million acre-feet to a minimum of 265,000 acre-feet. Conversely, under the conjunctive-use operation, annual ground water pumpage in the service areas has varied from more than one million acre-feet in dry years to a fraction of this amount in wet years.

Also in the 1950's, the Delta-Mendota Canal, in addition to providing for the exchange of water on the San Joaquin River, commenced delivering water to west-side lands which were experiencing overdraft and ground water quality problems.

Planning of The California Water Plan commenced in the late 1940's and in 1951 the initial unit of that Plan, the so-called "Feather River Project", was authorized by the Legislature. Bulletin No. 3 of the State Water Resources Board, entitled "The California Water Plan", was adopted by the Legislature in 1959. Funding of the initial unit of the Plan was approved by the electorate as Proposition 1 in the general election of November 1960. Among other purposes of this initial unit was the service of water to areas experiencing severe overdraft in Alameda, Santa Clara, Kings and Kern counties and southern California. First water delivered in the San Joaquin Valley was to Kern County in 1968. Institutional arrangements were made by the Kern County Water Agency, and member units thereof comprising 16 public water districts organized under various laws of the State to receive this water and integrate it with the then available supplies, including local surface water and ground water. Thus, a second major phase of conjunctive use involving a new source of water supply was initiated in the Valley.

Concurrently, the USBR was constructing its San Luis Unit of the CVP on the west side of the San Joaquin Valley. Certain of these facilities (San Luis Reservoir and San Luis Canal of the California Aqueduct) were constructed jointly with the State. Water from this project was first delivered to districts with ground water problems in 1967.

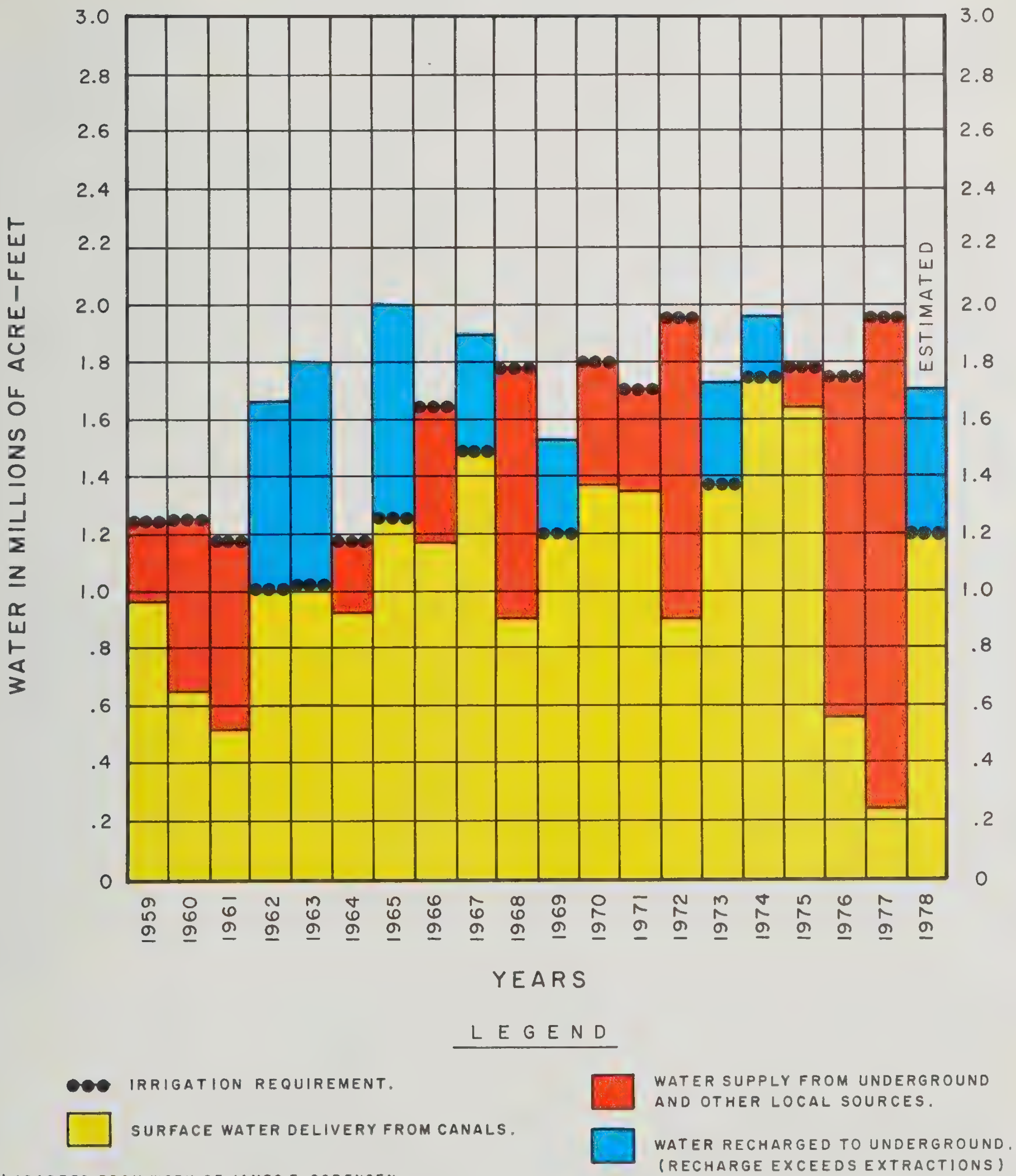
The Cross Valley Canal in Kern County, financed and constructed by local management entities, was completed in 1975 and linked the California Aqueduct of the SWP with the terminus of the Friant-Kern Canal of the CVP. The Arvin-Edison Water Storage District entered into agreements with 10 districts in Fresno, Tulare and Kern counties, located in the service area of the Friant-Kern Canal and Millerton Lake, which provided for an exchange of a portion of Arvin-Edison's contractual supply of water from Friant-Kern Canal for a supply of Federal water to be wheeled from the Delta through CVP and SWP facilities and the Cross Valley Canal to Arvin-Edison. This project, initiated and implemented locally, has provided a physical connection between State and Federal systems on the east and west sides of the Valley and the opportunity for increased operational flexibility between the two systems.

Similar to the history of southern California, the economy of the Valley has grown at a rapid rate and periodically has outstripped available water supplies. Reliance on ground water overdraft was temporarily required. With the introduction of new supplies of supplemental water, ground water use was reduced and a balanced condition of water supply and use prevailed for a period of time.

Status of Ground Water Management In the Southern San Joaquin Valley

In connection with this investigation, personal contact was made with representatives of more than 80 public and private entities in the southern San Joaquin Valley of which 63 are presently conducting ground water management programs.

The total area overlying usable ground water in the five-county area is about 3,900,000 acres. The survey showed that 3,391,000 acres, or nearly 90 percent of the total area overlying usable ground water, are within entities



NOTE: ADAPTED FROM WORK OF JAMES F. SORENSEN, CONSULTING CIVIL ENGINEER, VISALIA, CALIF. AND U.S. BUREAU OF RECLAMATION.

CONJUNCTIVE USE OF SURFACE AND GROUND WATER SUPPLIES

FRIANT-KERN CANAL AND MADERA CANAL SERVICE AREAS OF CENTRAL VALLEY PROJECT 1959 THROUGH 1978

BOOKMAN-EDMONSTON ENGINEERING, INC.

JANUARY 1979

TABLE 18

DEVELOPED AND UNDEVELOPED LAND OVERLYING USABLE GROUND WATER WITHIN AND OUTSIDE OF MANAGED AREAS

[1000 Acres]

County	Within Managed Areas				Outside of Managed Areas				Totals
	Developed	Undeveloped		Sub-(2) Total	Developed	Undeveloped		Sub-(4) Total	
		Irrigable	Non-(1) Irrigable			Irrigable	Non-(3) Irrigable		
Madera	179	5	0	184	120	66	0	186	370
Fresno	1,136	45	13	1,194	109	37	0	146	1,340
Kings	456	63	13	532	24	27	7	58	590
Tulare	519	78	4	601	69	47	3	119	720
Kern	713	122	45	880	0	0	0	0	880
Totals	3,003	313	75	3,391	322	177	10	509	3,900

(1) Land overlying ground water with uneconomic pumping depths, wildlife refuges and area reserved for brackish water disposal.

(2) Includes districts relying almost entirely on surface water.

(3) Land overlying ground water with uneconomic pumping depths.

(4) Includes districts not yet able to secure supplemental surface water.

having ongoing ground water management programs. About 509,000 acres, or 13 percent of the total area, are outside of the boundaries of management entities. The distribution of developed and undeveloped land within and outside of managed areas is shown for each county in Table 18.

As described in Chapter III, the land use surveys of DWR were reviewed to determine the amount of undeveloped irrigable land which has potential for development. It was determined that there are approximately 490,000 acres in the five counties which overlie usable ground water at depths which are considered economic for development. It was further determined that 322,000 acres of the 490,000 acres of economically developable land lie within areas which have management programs. Only 177,000 acres of irrigable undeveloped land, or slightly more than 4 percent of the area overlying usable ground water, are in unorganized areas which do not have management programs.

The land use surveys of DWR also revealed that there is presently a total of about 3,325,000 acres of developed land which presently receives water service. This includes all types of irrigated and urban lands. Of this amount, as indicated in Table 18, 3,003,000 acres, or 90 percent, are within managed areas and only about 322,000 acres of water-using land are outside of managed areas. Most of the 322,000 acres are presently devoted to irrigated agriculture.

Detailed information was obtained on the management programs for each entity and summaries thereof are set forth in Table A-1, entitled "Summary of Statistical Data for Entities Engaged in Ground Water Management in the Southern San Joaquin Valley", and in Table A-2, "Summary of Characteristics of Ground Water Management Programs in the Southern San Joaquin Valley".

Ground water management is being performed by cities, county agencies, and irrigation, California water, water storage, county water, and special act districts. In addition, mutual water companies and other private entities have active management programs. Table 19 presents a summary by county of the entities currently engaged in ground water management.

From statistical data in Table A-1, it is shown that nearly $500,000,000 have been expended by entities in the five-county area for the purpose of conjunctive use of surface and ground water resources. This value represents historical expenditures by public agencies and does not include substantial capital outlays made by the private sector for construction of wells and secondary conveyance systems utilized in the conjunctive-use operation. These entities utilize an average of about nine million acre-feet of water annually in their conjunctive-use operations. The total amount of the annual budgets of these entities is more than $70 million.

Table A-2 sets forth a compilation of the characteristics of various management programs as to types of recharge, methods of ground water recovery and other elements of the management programs. This table shows that of the 63 entities engaged in ground water management, 43 artificially recharge their ground water supplies directly in natural channels, unlined canals, cropped lands or spreading basins. Thirteen of the entities recover ground

water for use through entity-owned and operated wells. In the remainder of the management entities ground water is pumped by individual effort. Essentially all of the management entities use delivery of surface water in lieu of ground water pumping as a management tool.

Direct recharge of ground water in the southern San Joaquin Valley is accomplished through more than 15,000 acres of spreading basins, approximately 3,500 miles of unlined canals, several hundred miles of natural stream channels and an indeterminable amount of crop land. More than two million acre-feet of surface water has been intentionally recharged to ground water in these facilities and channels in a single year. These surface water supplies include local stream flow, CVP water and SWP water.

To aid in understanding the scope of water management activities in the southern San Joaquin Valley, a general discussion of ongoing programs in each county is found in the following sections. This overview is followed by a more detailed discussion of nine selected management programs.

Madera County

Madera County comprises the northeast portion of the study area and contains 299,000 acres of irrigated land. Principal urban area is the City of Madera.

Surface water is obtained from the San Joaquin River and its tributaries, Fresno and Chowchilla rivers, and Berrenda Slough, as well as from the Madera Canal.

Unconfined ground water is found beneath the Valley floor within the Chowchilla Water District and the Madera Irrigation District where replenishment largely occurs both naturally and from the conjunctive operations of the two districts. Ground water in the westerly portion of the County is obtained from both unconfined and confined aquifers replenished by underflow from the east.

Ground water management programs are underway, as shown in Table A-2, in the Chowchilla and Madera districts. These districts include 179,000 acres and 60 percent of the presently developed area. There are 71,000 acres of undeveloped land overlying usable ground water most of which is outside of managed areas.

With construction of Buchanan Dam on the Chowchilla River, the Chowchilla Water District now will be able to make more effective use of its contractual supply of Class 2 water delivered from the Madera Canal. Similarly, Madera Irrigation District utilizes Hidden Reservoir on Fresno River in its conjunctive-use program.

Fresno County

Fresno County extends across the San Joaquin Valley and is bounded on the north by the San Joaquin River and on the south by Kings and Tulare counties. There are about 1,250,000 acres of irrigated area in the County, and about 82,000 acres of undeveloped irrigable land overlying usable ground water.

Surface water is obtained from the San Joaquin and Kings rivers and from the Friant-Kern Canal and San Luis Unit of the CVP. Waters of the Kings River are distributed through an elaborate system of canals and distributaries of the River to, 28 districts and mutual water companies, located in Fresno, Kings and Tulare counties. Administration of the distribution of Kings River water is handled by the Kings River Watermaster on behalf of the Kings River Water Association and water rights holders on the River. San Joaquin River water is pumped to riparian lands and holders of appropriative rights largely in close proximity to the River. Water from Friant-Kern Canal is delivered to three contractors within the ground water area of the County. On the west side of the County, surface water is obtained from the Delta-Mendota and San Luis canals.

Ground water occurs in an unconfined state on the east side of the Valley and is replenished by the San Joaquin and Kings rivers, by percolation from minor streams and by recharge under the management programs of the numerous districts utilizing water from these rivers and from Friant-Kern Canal. Ground water of satisfactory quality for

TABLE 19
GROUND WATER MANAGEMENT ENTITIES IN THE SOUTHERN SAN JOAQUIN VALLEY

County	Cities	Irrigation Districts	California Water Districts	Water Storage Districts	County Water Districts	Special Act and Other Districts	Canal Companies	Totals
Madera		1	1					2
Fresno	1	5	5			1	3	15
Kings		3	1	1	1		2	8
Tulare		15	2			1	1	19
Kern	1	1	4	9 (1)	1	3 (1)	—	19
Totals	2	25	13	10	2	5	6	63

(1) Includes Improvement Districts

all beneficial uses is found on the east side. In the trough of the Valley, and to the west, usable ground water is also confined largely by the occurrence of Corcoran Clay. In the northwest side of the Valley, within Fresno County, the quality of ground water becomes progressively more saline from east to west and in some areas is unusable.

There are 15 entities in Fresno County now actively engaged in ground water management. 1,194,000 acres, or 89 percent of the total ground water area in Fresno County, lies within the boundaries of these entities as does 91 percent of the presently developed land. The physical characteristics of the east-side lands provide the opportunity for direct recharge and recovery of ground water supplies. Among the more significant and sophisticated of these programs are those of Consolidated Irrigation District and the Fresno Irrigation District-City of Fresno-County of Fresno, described in more detail hereinafter.

In the trough of the Valley, and on the west side thereof, the Corcoran Clay precludes direct ground water recharge and delivery of surface water in lieu of pumping is the ground water mechanism employed in management. Surface water is used to the maximum extent possible because of the undesirable quality of ground water and cost of production. Ground water is used for peaking and as a supplement to surface water in order to provide for a full irrigation supply for lands in this area.

Those areas without a surface water supply, and now in an unmanaged state, occur largely in the trough of the Valley and comprise some 109,000 acres of developed land and 37,000 acres of undeveloped irrigable land. About 53,000 acres of developed land and 4,000 acres of undeveloped irrigable land lie within the boundaries of the Raisin City Water District, which has no present surface water supply, but was organized to contract for a water supply from the East Side Project, and is now looking to the Mid-Valley Canal for supplemental water.

Ground water problems in Fresno County are reflected in lowering of ground water levels in certain of the east-side districts. This lowering, in recent years, has been accelerated by an inducement of ground water flow to the west by irrigation pumping on newly-developed lands in unorganized areas and within Raisin City Water District.

In the planning for water service from the USBR's Delta-Mendota Canal and San Luis Unit, it was estimated that a substantial amount of ground water could continue to be pumped in the Panoche, San Luis and Broadview water districts. The amounts of supplemental water contracted for by these districs were based on this premise. It is now found that the quality of ground water has not improved with the introduction of supplemental water and, in some areas, the quality has deteriorated to a point that it is unacceptable for continued irrigation use. This condition is not a result of ground water overdraft since ground water levels have stabilized or risen since the advent of supplemental surface water.

Delivery of the full contemplated contractual entitlements of CVP water to the Westlands Water District would satisfy requirements of existing development. However, additional water would be required for full development of District lands. Introduction of CVP water to Westlands and a reduction of pumping has resulted in a significant restoration of pressure levels in the confined aquifer from which most of the ground water has been obtained. Induced inflow from the east side of the Valley has thus been substantially reduced. Ground water pumping, which was required to maintain continuity of water delivery to District lands during the dry years of 1976-77, temporarily reduced pressure levels in the confined aquifer, but these levels were again restored in the "wet year" of 1978.

Kings County

Kings County is located in the approximate center of the Valley. Usable ground water occurs principally in confined aquifers. There are 480,000 acres of irrigated land and 90,000 acres of irrigable land presently undeveloped. The largest urbanized areas are the cities of Hanford, Lemoore and Corcoran.

Surface water is obtained from the Kings, Kaweah and Tule rivers, from the Friant-Kern Canal and from the California Aqueduct. In extremely wet years, Kern River water enters the County. Waters of the rivers are utilized under old established rights, under numerous and complex agreements and under court decrees. Principal entities administering operations under these rights are the Kings River Water Association, the Kaweah and St. Johns rivers associations and the Tule River Association. The Tulare Lake Basin Water Storage District has a maximum contractual entitlement to SWP water in the amount of 110,000 acre-feet per year. This contract is unique and recognizes local water availability, thereby providing a variable supply of SWP water to the District.

Ground water in the Kings County area is found in an unconfined state in the northeastern portion thereof and is largely confined by the Corcoran Clay and other impermeable strata in the balance of the County. Direct recharge operations are carried on in the northeastern area utilizing both local and imported waters. Little ground water is pumped directly within Tulare Lake Basin Water Storage District because of restricted aquifer yields and, in some areas, poor water quality. Additional ground water is pumped from outside the District for use on lands within the District. All ground water is extracted from privately-owned wells.

There are eight entities now engaged in ground water management in the County, which include an area of 532,000 acres, or 90 percent of the total. Almost all of the presently developed land lies within managed areas. Of the 90,000 acres of undeveloped irrigable land, 63,000 acres, or 70 percent, are included within managed areas.

An insufficient supply of surface water has resulted in a lowering of ground water levels in the easterly and northeasterly portions of the County and has induced

Photo Courtesy Kings River Water Association

At the Empire Weir No. 2 complex, waters of the Kings River are diverted into the Tulare Lake Canal [toward the upper right] and the Blakely Canal [toward the lower right] serving irrigation water to lands in the Kings River Delta.

ground water flow from Tulare and Fresno counties. Management entities in this part of the County are looking to the contruction of the Mid-Valley Canal to obtain required supplies of supplemental water.

In the Tulare Lake Basin Water Storage District, completion of the SWP and delivery of the District's full entitlement is being sought to eliminate reliance on an overdrafted ground water supply which is of less desirable quality than the imported supply. In this regard, the District is making arrangements to purchase Hacienda Water District's SWP water supply and other water rights of the Hacienda Ranch. The Tulare Lake Drainage District is concurrently arranging to purchase the lands of Hacienda Ranch, located immediately south of the Tulare Lake Basin Water Storage District. The lands will be taken out of agricultural production and used for drainage disposal and for storage of excess floodwater flows.

Tulare County

Tulare County, bounded by Fresno County on the north, Kings County on the west and Kern County on the south, has a presently developed area of 588,000 acres. There are 125,000 acres of undeveloped irrigable land overlying usable ground water. Principal urbanized areas are the cities of Visalia, Porterville, and Tulare.

Surface water is available to the ground water area of Tulare County from Kings, Kaweah and Tule rivers, minor streams and Friant-Kern Canal. There are 15 districts within the ground water area of Tulare County having long-term contracts for the delivery of CVP water, including five entities receiving water by exchange with the Arvin-Edison Water Storage District.

Ground water occurs in an unconfined state throughout the Valley portion of the County, with confined ground water in aquifers below the Corcoran Clay occurring in the central and westerly portion of the County near the trough of the Valley. Ground water is of satisfactory quality generally throughout the area, although some localized areas of inferior quality do exist.

There are 19 entities in Tulare County with active programs of ground water management. These manage-

ment programs include nearly all types of direct recharge of surface water. Ground water recovery is largely through privately-owned wells. Among the larger programs of ground water management are those carried on by the Kaweah Delta Water Conservation District, the Lower Tule River Irrigation District, and the Tulare Irrigation District, utilizing water from Friant-Kern Canal and local streams.

About 88 percent of the presently developed area lies within managed areas. Of the 125,000 acres of undeveloped irrigable land, 78,000 acres, or 62 percent of the total, are within managed areas.

There is a present ground water overdraft in the County, as manifested by a lowering of pressure levels in the confined aquifers in the westerly portion of the County, and by a progressive lowering of ground water levels along the easterly margins of the basin, particularly in the southerly part thereof in the Kern-Tulare Water District. The importation of additional CVP water through the Cross Valley Canal, obtained by exchange with Arvin-Edison Water Storage District, will act to mitigate the lowering of ground water levels, particularly in the Pixley Irrigation District and Rag Gulch Water District. The Kern-Tulare Water District is actively proceeding with plans to provide facilities for distribution of its full supply of Arvin-Edison exchange water which should alleviate the problem in that area.

Kern County

Kern County is located in the extreme southern end of the San Joaquin Valley and extends across the width of the Valley. There are now 713,000 acres of irrigated and urban lands overlying usable ground water and about 122,000 acres of irrigable undeveloped land. The principal urbanized area is the City of Bakersfield and its environs. The cities of Delano, Wasco and Taft constitute the other urban areas of significance.

Surface water is obtained from Kern River and in some years from Poso Creek, from Friant-Kern Canal, and from the California Aqueduct. The Kern County Water Agency has a contract with the State for 1.15 million acre-feet of water annually. Of this amount, about 740,000 acre-feet annually will be delivered under contract to 10 member units of the Agency overlying usable ground water. Both SWP water and CVP water are delivered through the Cross Valley Canal. This canal was constructed by the Agency on behalf of three of its member units and 10 entities in Fresno, Tulare and Kern counties receiving water by exchange with Arvin-Edison Water Storage District.

Ground water occurs in both unconfined and confined aquifers, with the Kern River alluvial fan comprising the principal area of ground water recharge. The mineral quality of ground water is generally satisfactory for irrigation and domestic use but is marginal to unsuitable in certain localized areas, particularly along the westerly edge of the basin where perched water tables occur.

The Kern County Water Agency, among its other functions, serves as an overall management vehicle for lands overlying the ground water basin. Through its taxation and assessment powers, the Agency provides a mechanism for achieving financial equity between lands having different sources and amounts of water. The Agency, in cooperation with the DWR, has developed a ground water model to assist in its management activities. Within the Agency boundaries and overlying usable ground water in the San Joaquin Valley, there are 19 public management entities, including entities which are State or Federal water contractors, entities using Kern River water and entities using a combination of these supplies. Each of these entities has an active program of ground water management, conjunctively utilizing surface and ground water resources. Sophisticated programs of ground water management have been undertaken by the City of Bakersfield in cooperation with Kern County Water Agency and several agricultural districts, and, among others by the North Kern, Arvin-Edison, and Semitropic water storage districts. These latter three programs are described in more detail hereinafter.

Improvement District No. 4 of the Kern County Water Agency, which includes the City of Bakersfield and adjacent areas, delivers SWP water obtained from Cross Valley Canal for both municipal and industrial use and artificial recharge. The Improvement District uses pump taxes, registration of wells and recordation of pumping as elements of its management program.

There is a current overdraft in Kern County manifested in a continued lowering of ground water levels, primarily in the SWP service area, wherein the full contractual entitlement to State water has not been received.

A saline water problem in the Buttonwillow Improvement District of the Semitropic Water Storage District will be eliminated by the introduction of the full allocations of SWP water to this area. Similarly, a problem of boron emanating from the bedrock complex to the east of the Arvin-Edison Water Storage District has been corrected by the introduction of CVP water to that District in 1966.

Selected Examples of Ground Water Management in the Southern San Joaquin Valley

As shown in Tables A-1 and A-2, the programs of ground water management in the southern San Joaquin Valley vary substantially. Individual management concepts differ depending on the physical characteristics of the management entity, such as topography, soils, geology, and the mode of ground water occurrence. Other influencing factors are: the source or sources of surface water and the characteristics of its occurrence; relative costs of obtaining and distributing surface water and of producing ground water; powers of the public body or structure of the private entity.

There is presented in this section a discussion of ground water management programs of eight public bodies and one private entity, which cover the range of management practices in the southern San Joaquin Valley and typify those of the 63 management entities therein.

Arvin-Edison Water Storage District

The Arvin-Edison Water Storage District was formed in 1942 under provisions of Division 14 of the California Water Code. The purpose of District formation was to acquire a supply of CVP water to eliminate overdraft in the District, reflected by a serious progressive decline in ground water levels and in the intrusion of boron from the bedrock complex underlying the District to the east.

The District comprises in excess of 130,000 acres of highly productive agricultural land located in Kern County in the extreme southeasterly portion of the San Joaquin Valley as shown on Plate 6, entitled, "Ground Water Management Entities." The District, for many years, has been essentially fully developed to irrigated agriculture with predominant crops including cotton, grapes, potatoes, citrus and vegetables. It includes the City of Arvin and, in the north, the East Niles area, an environ of the City of Bakersfield.

Sources of water supply for the District include ground water, CVP water obtained from Friant-Kern Canal, CVP water obtained from the Delta and delivered through the California Aqueduct and Cross Valley Canal by exchange and, from time to time, purchased Kern River water.

In the early 1960's, overdraft on ground water in the District approached 200,000 acre-feet annually. The District's annual contractual entitlements to CVP water consist of 40,000 acre-feet of Class 1 water, and up to 313,000 acre-feet of Class 2 water varying from zero to the maximum. The average annual amount of this variable supply is estimated to be 191,000 acre-feet.

Faced with an extremely erratic water supply and no available surface storage for local regulation, the District devised a plan of conjunctive use wherein the underlying ground water reservoir was directly utilized for seasonal and long-term carry-over storage. This required the construction of about 900 acres of recharge basins on the highly porous alluvial fans of the small streams discharging to the District from the east.

Surface distribution facilities were constructed to serve approximately 51,000 acres, which were intended to be irrigated from surface water alone. Some of the larger holdings in this service area have maintained wells for peaking and operational flexibility. The balance of the District continues to be irrigated from ground water, pumped through private wells from a stabilized ground water supply.

Surface water received by the District is delivered to the distribution facilities of the surface water service area to the extent there is a coincidental demand therefor. Water supplies that cannot be immediately used by the surface water service area are percolated in the recharge basins. In dry years, as in 1976 and 1977, or in years when insufficient surface water is available in the summer and fall months to maintain continuity of irrigation delivery to the surface water service area, water previously stored underground is pumped into the surface distribution system from 55 District-owned and operated wells.

Over the long-term period, approximately one million acre-feet of ground water storage capacity will be utilized to regulate the District's water supply. Geologic studies show that there is in excess of this amount of capacity available for this purpose.

Facilities needed to accomplish the conjunctive operation include 34 miles of concrete lined canal, over 75 miles of pressure pipeline, a 26,000 hp main pumping plant, 48 booster pumping plants and the aforementioned 55 wells and 900 acres of recharge basins. These facilities were completed in the mid-1960's at a cost of $46 million.

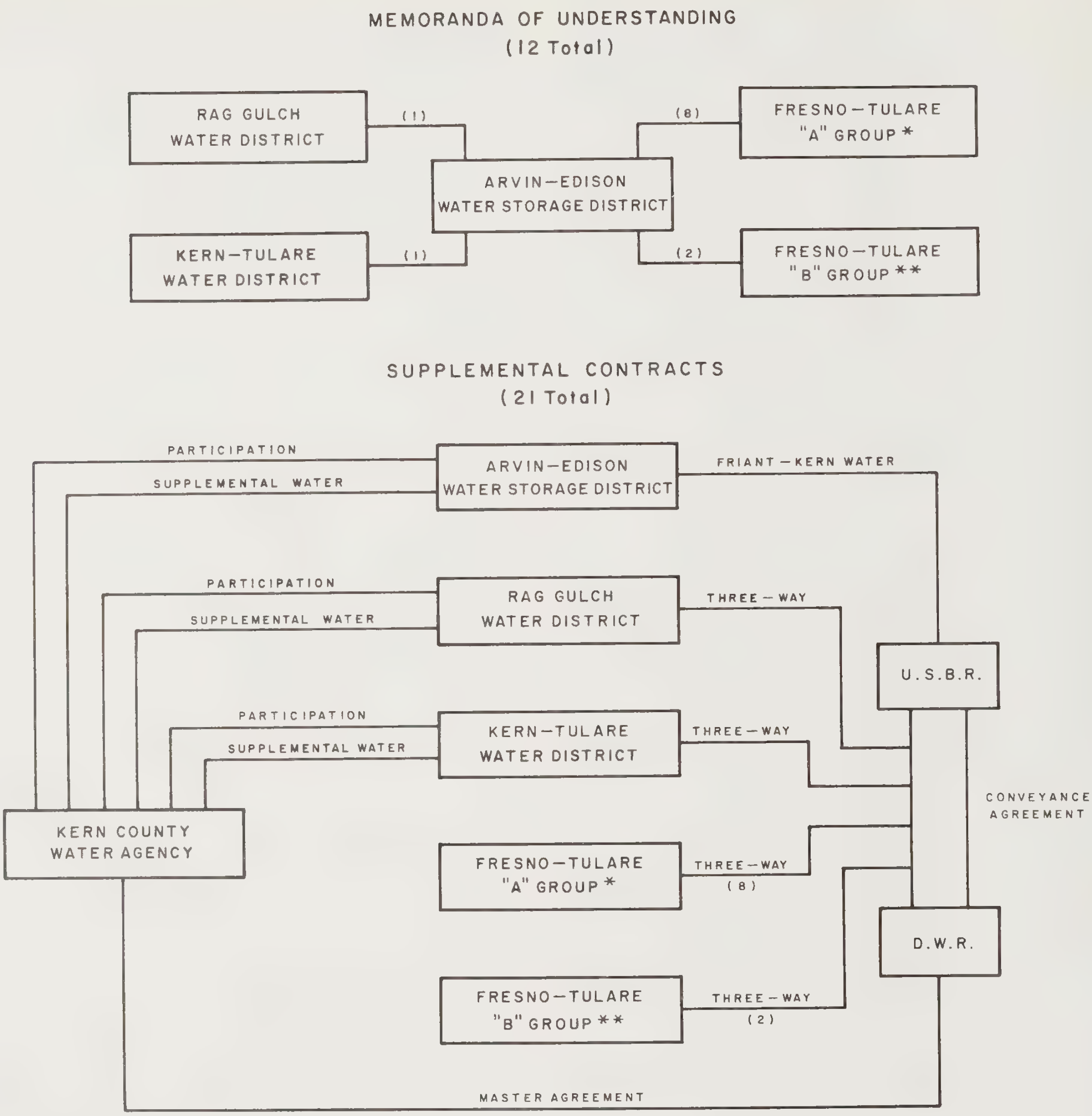
In 1974, the District entered into agreements with ten northerly entities in Fresno, Tulare and Kern counties, providing for an exchange of a portion of the District's supply from Friant-Kern Canal for a supply of CVP water pumped from the Delta through the California Aqueduct and thence through the Cross Valley Canal to a point of delivery at Arvin-Edison Water Storage District's Intake Canal. These ten entities each executed separate contracts for CVP water with the United States and participation agreements with several other public entities to provide for the funding and construction of the Cross Valley Canal. A separate wheeling agreement was excecuted between the DWR and the USBR for use of the California Aqueduct. In all, 33 separate agreements were required to effect the exchange.

Figure 4 shows the contractual relationships between the 14 entities involved in the exchange. The exchange program provides for a firm delivery of 128,300 acre-feet of water annually to the Arvin-Edison Water Storage District through the California Aqueduct and the Cross Valley Canal. Up to 174,300 acre-feet of the District's entitlement in Friant-Kern Canal is delivered to the exchangors, which entitlement over the long-term period is expected to yield an average of 128,300 acre-feet annually. The District benefits from this program by receiving better regulation of its surface water supply. The exchangors benefit by receiving an average of 128,300 acre-feet of new water which could not have been obtained without the exchange.

Arvin-Edison Water Storage District utilizes direct recharge and the service of surface water in lieu of pumping as recharge mechanisms. Through its exchange program, it is effectively providing substantial additional recharge in absorptive areas for nearly 100 miles to the north on the east side of the Valley.

Operation of the District's management program is funded by revenues obtained from delivery of water under contracts with landowners in the surface water service area and from service charges levied on lands irrigated from

FIGURE 4



TOTAL OF 33 AGREEMENTS

* FRESNO—TULARE "A" GROUP:

FRESNO COUNTY (SHAVER LAKE—AUBERRY CRESCENT SERVICE AREA AND SKY HARBOR SUBDIVISION).

HILLS VALLEY IRRIGATION DISTRICT.

TRI—VALLEY WATER DISTRICT.

HOPE WATER DISTRICT.

DUCOR IRRIGATION DISTRICT.

TULARE COUNTY.

LOWER TULE RIVER IRRIGATION DISTRICT.

PIXLEY IRRIGATION DISTRICT.

** FRESNO—TULARE "B" GROUP:

LOWER TULE RIVER IRRIGATION DISTRICT.

PIXLEY IRRIGATION DISTRICT.

CROSS VALLEY CANAL EXCHANGE PROGRAM

BOOKMAN—EDMONSTON ENGINEERING, INC.   JANUARY 1979

The Arvin Edison Water Storage District's Sycamore Spreading Works percolate wet-year CVP water supplies to underground storage for extraction and distribution to District lands during dry years.

both surface and ground water sources. By this latter means, financial equity is obtained between the surface and ground water service areas.

The management program of the Arvin-Edison Water Storage District has been successful in stabilizing ground water levels and stopping the intrusion of boron into the ground water supply. During the dry years of 1976 and 1977, withdrawals of previously stored ground water sustained the irrigated agricultural economy of the District.

Consolidated Irrigation District

The Consolidated Irrigation District, located in southern Fresno County, as shown on Plate 6, was organized in 1921 for the purposes of securing and distributing a supply of irrigation water to an area of about 150,000 acres. The District obtains its surface water supply principally from Kings River. From time to time, CVP water is also obtained under a short-term Class 2 contract with the United States. Principal crops in the District are grapes, deciduous fruits, cotton, alfalfa and nuts.

Approximately 90,000 acres are supplied with surface water. Because of the variable nature of these supplies, all surface-supplied lands also can be supplied from wells. About 60,000 acres of District lands are supplied solely from ground water. There are approximately 4,500 irrigation wells in the District.

The District uses a combination of water tolls and charges to achieve financial equity between surface and ground water users.

The District manages one of the oldest and largest, conjunctive-use programs in the Valley. In the early 1930's the District recognized the necessity of artificially recharging its underlying ground water supplies and embarked upon a program of purchasing recharge sites, which program continues to the present. The District now has 46 recharge basins comprising an area of about 1,500 acres. Additionally, approximately 370 miles of unlined conveyance canals are utilized in the recharge operations. The District is largely comprised of pervious soils with direct hydraulic continuity between the surface and ground

water. All ground water is pumped from unconfined aquifers.

Over the past 25 years, the District has intentionally recharged approximately 1.5 million acre-feet in its recharge basins and canals. During 1969, a total of 308,000 acre-feet of water was artificially recharged to the ground water basin and, in 1978, approximately 180,000 acre-feet were recharged. The excellent recharge capability of the area is shown by the fact that, in past years, as much as 1,400 acre-feet of water per day have been recharged continuously for a period of several months.

In addition to the utilization of entitlements to Kings River and CVP waters, the District utilizes purchased water and transferred supplies in its recharge operation. The District recently entered into an agreement with the Selma-Kingsburg-Fowler Sanitation District to take treated sewage from the Sanitation District's treatment plant and deliver it to recharge basins, or comingle it with other supplies of surface water for irrigation of row crops. Eventually, 6,100 acre-feet of water will be obtained from this source.

Consolidated Irrigation District provides an example of a large-scale conjunctive-use program utilizing both imported and local waters as well as urban waste waters in its operations. In spite of these efforts, the District continues to be water deficient and is looking to outside sources for a supplemental water supply.

Fresno Irrigation District, et al.

One of the most unique water resource managment programs in California is that which has been developed through the cooperative efforts of Fresno Irrigation District, City of Fresno, City of Clovis, 15 county water works districts, and the Fresno Metropolitan Flood Control District. The program involves the conjunctive use of surface and ground water, storm water control and waste water management in an area where productive agricultural land is undergoing urbanization.

Fresno Irrigation District was formed in 1920 as a successor in interest to Fresno Canal and Land Corporation, successor in interest to Fresno Canal and Irrigation Company which had been diverting water from Kings River since 1871. The District's rights to Kings River water average about 415,000 acre-feet annually. In addition, the District has a contract with the USBR for 75,000 acre-feet of Class 2 water and the remainder of City of Fresno's Class 1 water, which decreases annually in increments of 2,000 acre-feet and is presently (1979) 29,000 acre-feet. The average supply of CVP water under these contracts is presently 64,000 acre-feet annually.

The District contains about 245,000 acres and is essentially fully developed to a wide variety of high-revenue crops and urban and suburban lands. Approximately 160,000 acres receive surface water. Available surface water is supplemented by private pumping for irrigation use. The District does not provide direct service to urban and suburban entities.

The District has approximately 740 miles of canals and pipelines, of which 180 miles of canals have a carrying capacity of 50 cfs or more. Operations are funded from service fees based on the value of service provided by the District to the land.

The District has experienced substantial urbanization since World War II and now contains a population estimated to be more than 300,000, included within the cities of Fresno and Clovis and their environs. All water served by Fresno, Clovis and the county water works districts serving the unincorporated areas, is obtained from ground water. Heavy concentration of pumping, particularly by the City of Fresno, developed a substantial cone of depression in the ground water table. This led to the evolution of a cooperative water resource management plan between the District and the City of Fresno. The concept of the plan has been extended to include the 15 water works districts and the City of Clovis.

The City of Fresno has an entitlement to 60,000 acre-feet of Class 1 water from the CVP. Neither the City of Fresno, the waterworks districts nor the City of Clovis have treatment facilities to enable the direct use of surface water.

The District, through its facilities, delivers some 15,000 acre-feet of the City of Fresno's contractual supply of CVP water to percolation in an artificial recharge basin within the metropolitan area. This basin, named "Leaky Acres", is located within the City limits and overlies the cone of depression in the ground water table created by the City's pumping. It comprises 117 acres of pervious soils.

Additionally, the District delivers for irrigation use and artificial recharge, surface water available to the District and appurtenant to lands now urbanized, to locations which would benefit pumping by the City and the water works districts. A similar arrangement is carried out with the City of Clovis, and a 70-acre artificial recharge basin owned by that City is utilized in the operation.

Through these cooperative efforts, an efficient conjunctive-use operation is carried out, eliminating the necessity for construction of expensive treatment and duplicate conveyance facilities.

The District also, in cooperation with the Fresno Metropolitan Flood Control District, utilizes during the irrigation season, five artificial recharge basins constructed by the Flood Control District which basins, to the extent possible, are utilized for the percolation of storm water during the rainy season. It is planned to add recharge basins to the program as funds become available.

Of particular interest is the cooperative arrangement between Fresno Irrigation District and the City of Fresno with respect to waste water management and reclamation. Waste water, including winery stillage wastes which have been subjected to secondary treatment, are discharged to a 2,000-acre infiltration bed to percolate to ground water thereby effecting tertiary treatment. The City extracts ground water from beneath the infiltration beds through 21 wells which discharge into the Fresno Irrigation District

canal system. In turn, for each two acre-feet of water pumped into the District's system by the City, the District furnishes approximately one acre-foot of fresh water from its surface supplies. This water is delivered to the easterly portion of the District and in areas that can best be used to recharge the underground supply to benefit the City's municipal wells. In 1978, the passage of SB 2046 by the Legislature provided a means by which charges could be levied on lands undergoing urbanization, to provide funds for recharge facilities. This bill was supported by and will be of benefit to the foregoing entities in their cooperative programs.

The ground water management program in the Fresno area provides an excellent example of local cooperation and ingenuity in developing a conjunctive-use program to accommodate complex problems of water and waste management occurring with the urbanization of agricultural lands.

Kings County Water District

The Kings County Water District, located in the northeast portion of Kings County as shown on Plate 6, was chartered in 1954. The following is quoted from "A Report — Kings County Water District," dated 1967:

> "The primary function of the Kings County Water District is to conserve water, make available local and imported surface supplies, and stabilize a reasonable water table in the upper strata beneath the District's service area. Water for this storage program comes from many sources, but is delivered through the Kings and Kaweah Rivers to settling basins, sloughs, and depressions where it can percolate underground . . . . . .
>
> "This four point program outlines the District's basic aims:
>
> 1. To protect, conserve, and stabilize the underground supply of water.
> 2. To contract and work for new sources of water.
> 3. To maintain the facilities and capabilities to utilize and conserve those supplies that become available.
> 4. To preserve the existing water rights that are now within the District."

Achievement of the foregoing is carried out under a complex program administered by the staff and advisors to the District. A detailed technical analysis of the activities and accomplishments of the District is set forth in "District, Surface Water Inventory, Groundwater Conditions and Related Data" by R. L. Schafer & Associates, Inc., January 21, 1976, Updated February 1978.

The District comprises about 143,000 acres, within which is situated the City of Hanford. Irrigated agriculture commenced in this area in the early 1870's with diversions from the Kings and Kaweah rivers. The District is essentially fully developed to irrigated agriculture with some 133,000 acres now in crop production. The current annual water demand in the District is 410,000 acre-feet.

The District acts as a management entity to purchase surface water, when available, and either percolate it to the underground in natural channels and recharge basins in the area of unconfined ground water in the north and east parts of the District, or deliver such water for irrigation through facilities of private ditch companies. All ground water is pumped through private wells.

The District acts solely as a management agent on behalf of landowners and public and private water supply entities within its boundaries. It owns no facilities other than lands used for ground water recharge. It provides the necessary coordination and integration between users of local surface water and ground water and provides the mechanism through which needed additional water supplies for conjunctive operation can be obtained. Ad valorem taxes have provided most of the revenue to fund the District's operation.

The District, since its inception, has carried out a program of purchasing stock in the Peoples and Settlers ditch companies and Last Chance Water Ditch Company, which companies hold water rights on the Kings River, in order to prevent transfer of stock of these companies and rights to Kings River water to lands outside of the District. Kings County Water District has also purchased stock in the Lakeside Ditch Company which has rights to waters of the Kaweah River. The average annual supply from these rights is 140,000 acre-feet.

Additionally, the District has a short-term contract for CVP water executed in 1958. From time to time, the District also obtains water surplus to the needs of CVP long-term contractors and to water rights holders on the Kings and Kaweah rivers. Through exchanges and purchases over the past 22 years, the District has acquired, on the average, an additional supplemental surface water supply of 23,000 acre-feet per year. The District has had a continuing program of acquiring natural channels and areas for construction of recharge basins in absorptive areas of the District. The District now has over 2,000 acres of recharge area and also uses some 230 miles of unlined canals owned by the ditch companies. It has percolated more than 100,000 acre-feet of water in a single year.

The District maintains an active program of monitoring hydrologic conditions, including water supply and use, ground water pumping, changes in ground water storage and underflow to and from the District. This is done in cooperation with the DWR and other agencies. From analysis of data obtained from this program, it is estimated that 100,000 acre-feet annually of supplemental water is required to achieve hydrologic balance in the District.

The Kings County Water District is looking to the Mid-Valley Canal for additional water supplies needed in its conjunctive-use operation to stabilize its receding ground water levels.

The District provides an example of an extremely well-managed area making full and efficient use of its available water resources in cooperation with both private

and public entities. It is typical of numerous east-side management entities that require additional supplemental water to integrate into their conjunctive-use programs.

Lemoore Canal and Irrigation Company

The Lemoore Canal and Irrigation Company is a mutual water company formed in 1904. Its service area contains some 53,000 acres located in Kings County in the trough of the Valley southwest of the City of Fresno, as shown on Plate 6. Lands served by the Company have been essentially fully developed for many years.

This Company provides an example of a long-time ground water management program being carried on by a private entity.

The Company has entitlements to and obtains surface water from the Kings River. It delivers its Kings River supply through approximately 100 miles of unlined canal. In addition, included within the Company's service area are Stratford and Empire West Side irrigation districts and John Heinlen Mutual Water Company, each of which has entitlements to Kings River water. Stratford Irrigation District also owns stock in Lemoore Canal and Irrigation Company and obtains water from that source.

There is sufficient stock in the Company to provide full water service to approximately 34,000 acres. The balance of the irrigated land in the Company's service area relies on ground water pumpage for its irrigation needs except in years of above average water supply when, through appropriate arrangements, surface water is delivered to certain of these lands. Lands regularly supplied with surface water also either have wells thereon or access to wells, which are used in varying degrees depending upon the amount of stock ownership. Thus, surface and ground water available to Company lands and to the irrigation districts and the mutual water company within its service area are conjunctively used, and the respective amounts utilized from each source in a given year are a function of the availability of Kings River water in that year.

Geologic conditions within the service area of the Company prevent direct recharge to the deeper confined aquifers from which most of the ground water is obtained. In addition to employing the use of surface water, in lieu of ground water pumping, as a management tool to maintain ground water levels, the Company has transferred surface water to adjacent absorptive areas for recharge. In 1978, 20,000 acre-feet were so transferred to Consolidated Irrigation District and 5,000 acre-feet to Kings County Water District, located north and east, respectively, of the Company's service area, for ground water replenishment. Recharge of this water in these upper lying areas directly replenished the deeper aquifers underlying Lemoore Canal and Irrigation Company lands.

In order to prevent a buildup of a perched water table in the upper aquifers, and the creation of drainage problems, the Company has encouraged the private pumpers to perforate wells both above and below confining clays.

The management program of the Company, utilizing conjunctive use of Kings River water and ground water, together with its indirect recharge activities, has resulted in creation of a stabilized ground water condition in the area. Although the Company does not have taxing or assessment powers, through the activities described, it has been able to achieve its management objective and also establish financial equity between its surface and ground water users.

Lower Tule River Irrigation District

The Lower Tule River Irrigation District is located in the south-central portion of Tulare County, as shown on Plate 6, and was formed in 1949 for the purpose of obtaining supplemental water from the CVP to utilize conjunctively with a failing ground water supply. An additional purpose of the District was to promote flood control on the Tule River.

The District contains about 103,000 acres, of which about 88,000 acres are presently irrigated. Principal crops are cotton, alfalfa and irrigated grain and hay. Undeveloped lands are either nonirrigable or of poor quality. District lands generally overlie unconfined ground water readily recharged from the surface, although the permeability of the surface soils diminishes in the westerly part of the District. The Tule River and its distributaries extend throughout the length of the District, from east to west, and constitute a source of surface water for irrigation and ground water replenishment.

In addition to supplies available from the Tule River, the District has a permanent contract with the United States for delivery of CVP water from Friant-Kern Canal, which contract provides 61,200 acre-feet of Class 1 water and a maximum of 238,000 acre-feet of Class 2 water per year. The average annual supply under this contract approximates 180,000 acre-feet. In 1974, the District entered into an exchange agreement with Arvin-Edison Water Storage District and executed a contract for additional CVP water in the amount of 31,100 acre-feet per year, which supply is delivered to Arvin-Edison. A portion of Arvin-Edison's CVP supply is delivered to Lower Tule River Irrigation District from Friant-Kern Canal. This supply, being largely Class 2 water, varies from zero to about 52,000 acre-feet per year. The District issued $2.2 million of general obligation bonds to finance its participation in Cross Valley Canal and for internal improvements. With the addition of exchange water, District water supplies are considered in balance with water use if subsurface outflow is neglected.

Since water supplies from all District sources are extremely variable from year to year, all lands in the District have a dual water supply, i.e., both surface and ground water. Distribution system facilities have been constructed through improvement districts to provide surface water service. Ground water is pumped entirely through private wells.

In years of above average water supply, water in excess of direct irrigation needs is percolated to the underground: in 300 acres of recharge basins acquired specifically for this purpose; in 34 1/2 miles of Tule River channel; in unlined distribution canals; and by off-season irrigation where land use and cropping patterns permit.

A unique provision of the water supply contracts between Cross Valley Canal exchangors and the United States effectively provides for an integrated operation of the east and west-side water sources. In years of substantial runoff, as 1978, Cross Valley Canal supplies to be delivered to Arvin-Edison are reduced or eliminated, and this reduction is compensated for by increased deliveries of water from Friant-Kern Canal to Arvin-Edison. By this means, substantial energy costs for pumping water from the Delta and through Cross Valley Canal are eliminated.

Historically, the District has experienced substantial ground water outflow, principally to the Pixley Irrigation District lying immediately to the south. Pixley Irrigation District was not a long-term contractor for CVP water but, in 1974, also entered into the Cross Valley Canal Exchange Program and is now receiving CVP water. As a result, it is anticipated that the historical rate of ground water outflow from Lower Tule will be reduced.

The District, under irrigation district law, uses water tolls and assessments to fund its management program. Since all lands receive a dual water supply, it is relatively easy to establish financial equity between surface and ground water users.

The management program of Lower Tule River Irrigation District is typical of programs of those east-side entities using both CVP water and local water. This District, together with the other entities in the Exchange Program, provide the mechanism by which east-side local waters, Millerton Lake supplies and water supplies from the Delta are integrated into a conjunctive operation with ground water resources.

The Lerdo Canal on the right brings Kern River water to North Kern Water Storage District spreading facilities for recharge of ground water supplies used on adjoining irrigated lands.

North Kern Water Storage District

North Kern Water Storage District was formed in 1935 under provisions of Division 14 of the California Water Code. As shown on Plate 6, it is located north of the Kern River and comprises some 60,000 acres (exclusive of James-Pioneer Improvement District) of intensively-farmed, highly productive agricultural lands. The District lies between the City of Bakersfield on the south, the City of Delano on the north and is west of Highway 99. It has been essentially fully developed for many years.

The area now included within North Kern Water Storage District was one of the earliest in California to be considered for ground water management and investigations date back to 1913. Detailed investigations and proposals for a ground water management plan involving the conjunctive use of Kern River water were presented in a report entitled "Kern River Water Storage District" by A. L. Trowbridge, dated December 21, 1928. This comprehensive document set forth the water management concept currently being carried out by the District.

When the District's program was initiated in the mid-1930's, Kern River was unregulated. Construction of Isabella Dam and Reservoir in the 1950's and purchase of conservation space therein by the District, improved seasonal regulation of the District's surface water supply.

The basic concept of the District program is similar to the conjunctive-use program of Arvin-Edison Water Storage District, wherein approximately one-half of District lands, or some 30,000 acres, are supplied by the District with both surface water and District-extracted ground water. The remaining 30,000 acres are served almost entirely from ground water pumped from private wells. Kern River water is delivered to the surface water service area to the extent there is a coincident demand therefor. Kern River water surplus to immediate irrigation requirements is introduced directly into the underground through 1,500 acres of recharge basins. As much as 150,000 acre-feet of water has been artificially recharged to ground water in a single year. In years of deficient water supply, continuity of delivery to the surface water service area is maintained by the operation of 52 wells owned and operated by the District.

The annual Kern River water supply has varied from 25,000 acre-feet to more than 300,000 acre-feet. Ground water pumpage from District wells has varied from no pumping in "wet" years, to 65,000 acre-feet per year in "dry" years. Delivery of surface water is accomplished through approximately 130 miles of unlined canals heading at two points of diversion at Kern River, 20 miles of pipeline and 25 miles of lined canal. In wet years, maximum use is made of the unlined canals to augment recharge. In dry years, the lined canal system is utilized to bypass a portion of the unlined canal system that has heavy seepage loss.

Financial equity between surface and ground water users is achieved through a combination of water tolls for surface delivery and service charges on lands irrigated from ground water.

Although the District's water supply and use is in balance, underground escape of water occurs to adjacent areas experiencing overdraft. The District has adopted a policy of participating in exchanges and other cooperative endeavors in an attempt to provide surplus surface waters to these areas when available. The advent of SWP water in Kern County and the availability thereof to these adjacent areas should stabilize ground water levels and mitigate or eliminate the outflow of ground water, provided full contractual entitlements to SWP water are delivered.

The program of the North Kern Water Storage District, now having been operated for more than 40 years, provides an excellent example of sophisticated management of an erratic local water supply in conjunction with ground water storage wherein, although the District itself is in water balance, adjacent overdrafted areas have induced a ground water flow from the District. These adjacent areas are now managed and with the delivery of their full contractual entitlements of SWP water, ground water levels should be stabilized.

In 1978, 37,400 acres of land adjacent to Kern River, and lying southwest of the original North Kern Water Storage District, were organized as the James-Pioneer Improvement District of North Kern Water Storage District. Within the Improvement District are 24,650 acres of irrigated land and 6,650 acres of undeveloped irrigable land. The area is primarily irrigated from wells although surface water, when available, can be utilized to serve a substantial portion of the area through a system of canals and ditches. Owners of land within the Improvement District have a contractual supply of Kern River water estimated to average 15,000 acre-feet per year. This supply would be used for either direct irrigation or ground water replenishment. Approximately 45,000 acre-feet of Kern River water were diverted by, and utilized within, the Improvement District in 1978. A purpose of forming the Improvement District was to establish a public agency which would be in a position to acquire surface waters from several possible sources, including surplus water from Cross Valley Canal which extends through the Improvement District. As part of the overall management program of Kern County Water Agency, lands within the Improvement District were assessed in 1975, 1976 and 1977, under the Zone of Benefit provisions of the Agency Act. The basis of the assessments was an improvement in ground water conditions underlying these lands from SWP water, as determined by the Agency. No benefit assessment was levied in 1978.

Semitropic Water Storage District

The Semitropic Water Storage District was formed in 1958 to provide an institutional mechanism to obtain supplemental water from the SWP in order to eliminate a serious ground water overdraft in the District, manifested

in a worsening water quality problem in a portion of the District, land subsidence and a general decline in ground water levels throughout the District.

The District comprises 224,000 acres located in the trough of the Valley in the north portion of Kern County, as shown on Plate 6. Because of substantial differences in ground water conditions and problems, two improvement districts were formed in 1965, i.e., Buttonwillow Improvement District and Pond-Poso Improvement District, which comprise about 70 percent of the total area of the District. Three separate water supply contracts were entered into with the Kern County Water Agency for supplies of SWP water which, in the aggregate, provide an annual entitlement of firm water of 158,000 acre-feet. Except for surface waters obtained from Poso Creek in years of above average water supply, the District is entirely dependent upon ground water and SWP water to meet its demands. The District has recently obtained a permit to appropriate waters of Poso Creek and is developing a plan for the integration of this supply and surplus waters from Friant-Kern Canal into its program. Included in this plan is the consideration of direct artificial recharge.

There are presently 120,000 acres under irrigation in the Semitropic Water Storage District which, for the most part, are located within the two improvement districts, with principal crops being cotton, alfalfa and field crops. The balance of undeveloped District lands are of inferior quality with substantial depths to ground water and would not be expected to develop, except under the most favorable of economic conditions.

Approximately $30 million has been expended by the improvement districts in the construction of facilities for the conjunctive operation of their supplies of SWP water with ground water. These facilities include 41.5 miles of unlined canal, 135.3 miles of pressure pipeline and 11 pumping plants. The management concept is to stabilize ground water levels and correct the subsidence and ground water quality problems, by delivery of surface water to selected areas, to be used in lieu of pumping ground water, with the balance of lands to be irrigated from a stabilized ground water supply of good quality.

In the aggregate, 176 individual water service contracts were entered into between the two improvement districts and landowners, for the delivery of 150,000 acre-feet of firm water. The balance of the water entitlement available to Semitropic Water Storage District is to be held in reserve for service outside of the improvement districts or, within these entities, depending on need.

Facilities of the Buttonwillow Improvement District went into operation in 1973 and those of Pond-Poso Improvement District in 1977. Planning of the improvement districts' projects contemplated delivery of essentially the full 150,000 acre-feet annually in the first year of operation of both projects. Since contracts with the Kern County Water Agency provide for a buildup in firm deliveries, supplies of surplus water to be obtained by the Agency from the State were scheduled to make up the differences between the firm entitlements in a given year and the maximum entitlements.

In common with other entities in the SWP service area in Kern County, and in accordance with the requirements of their financial programs, the improvement districts will be forced to collect revenue to meet fixed obligations under contracts in the surface water service areas, by service charges on ground water users, without receipt of contemplated full supplies of SWP water. Without completion of SWP, ground water overdraft will continue, with declining ground water levels and accompanying increased energy charges for ground water extractions. Revenues must be collected to meet bond payments and loan obligations to the Federal Government for construction of program facilities.

Additionally and contrary to the program plan, it will be necessary that wells be maintained by landowners, at substantial cost, to supplement the inadequate surface supply.

Thus, Semitropic Water Storage District and its improvement districts have developed efficient management programs and undertaken substantial fiscal obligations to implement these programs. At this time, the program lacks one essential element, i.e., a supply of supplemental surface water in the amount contemplated to carry out the carefully planned and expensive conjunctive-use operation. This serious financial situation typifies that of other districts in the Kern County Water Agency relying on SWP water for conjunctive use with underlying ground water.

Westlands Water District

Westlands Water District, a California water district, was organized in 1952 under Division 13 of the California Water Code. It contains approximately 603,000 acres located on the west side of the San Joaquin Valley in Fresno County, as shown on Plate 6. The District was formed to obtain a supplemental water supply from the San Luis Unit of the CVP and is the largest contractor in terms of acreage and water supply in the CVP.

In common with other west-side management entities, usable ground water in Westlands Water District occurs in two aquifer zones, an unconfined zone overlying the Corcoran Clay, and a confined zone below the Clay which is the principal source of usable ground water. Replenishment to the confined zone is primarily by underflow from the east side of the Valley with some underflow from the west side. Ground water in the upper zone is for the most part unsuitable from a quality standpoint for irrigation of many crops. The District's contract with the United States provides for an annual entitlement of 900,000 acre-feet, but the District and the United States are negotiating to increase this amount to 1,150,000 acre-feet. At the present time, the District's distribution system is about 80 percent complete and approximately $158 million have been expended thereon.

Most of the ground water used in the District is pumped from the confined lower zone. Prior to introduction of supplemental water, pressure levels in the lower ground water zone exhibited a progressive lowering, and ground water flow from the east side was being induced at an ever increasing rate to meet pumping demands. Land subsidence became a significant problem. Subsequent to the delivery of CVP water, ground water extractions from beneath District lands, which at one time approximated one million acre-feet annually, were reduced to 97,000 acre-feet in 1976, and pressure levels in the lower zone had risen approximately 150 feet above preproject levels. This substantially reduced ground water underflow from the east side. However, during the drought year of 1977, wherein the District's water supply along with other CVP irrigation contractors was reduced to 25 percent of its entitlement, pumpage increased to 472,000 acre-feet. In the wet year of 1978, pumpage was again reduced to an amount estimated to be less than 100,000 acre-feet.

The primary impediment to the use of ground water in the upper zone is its unsatisfactory quality. Several plans of blending surface and ground water and utilizing the blended supply in various parts of the District have been considered. Studies have been made to construct as many as 450 wells to pump as much as 463,000 acre-feet of ground water annually. Westlands Water District, as a California water district, has adequate statutory authority to proceed with such a program and equitably distribute the cost thereof, provided a feasible plan can be developed.

The District under its current management plan has succeeded in marketing its available surface water supply and in reducing ground water extractions to a fraction of those occurring prior to the introduction of supplemental water. This has been done through economic inducement.

Under California water district law, all District lands with the same class of rights are entitled to a pro rata share of the District's available water supply and also are obligated to pay a pro rata share of the District's repayment obligation for distribution system construction. Thus, there exists an economic pressure for full utilization of the imported water. Since the District's present contractual water supply is inadequate to provide a full water supply to all District lands, continued overdraft of the lower confined ground water zone offers the only presently available source of water. Such pumping will continue to reduce pressure levels in the confined zone and induce more ground water flow from the east side.

Full utilization of District lands will require approximately 400,000 acre-feet per year of additional supplemental water, in addition to the 250,000 acre-feet presently under negotiation. A portion of this supplemental requirement may be obtained from the upper ground water zone if a feasible plan for utilization of this water can be developed.

Photo Courtesy U. S. Bureau of Reclamation

Water released from the California Aqueduct into a siphon under the Kern River Outlet Canal, flows into the Cross Valley Canal, which extends to the east side of the Valley, serving the Bakersfield urban area, and providing for conjunctive use of CVP, SWP and local water supplies.

CHAPTER VII
ECONOMICS OF AGRICULTURE

California agriculture is a complex and dynamic industry. It is one of the State's leading industries and ranks first in the value of its products among the 50 states. In 1976 and 1977, the value of farm production in California amounted to $9.1 billion and $9.3 billion, respectively, both being records for the State, even though extreme drought conditions prevailed throughout most of the State in 1977. Ground water supplemented the reduced surface supplies and saved agriculture that year. Over 10,000 new wells were drilled in 1978. Preliminary estimates for 1978 indicate another record high, $10.1 billion, according to a Bank of America estimate.

The statistics on California's agriculture are ones of superlatives that reflect the importance of agriculture to the economic and social well-being of the State. The importance of agriculture to civilization historically has been pointed out by Dr. Emil Mrak, Chancellor Emeritus at U.C. Davis, in an article "The Farmer: Up Against the Wall", September/October 1973 issue of Pacific Business.

> "One thing is clear, and that is that no civilization has become great without a great agriculture, and no civilization has remained great if its agriculture has not remained great —— unfortunately so few seem to realize this."

The impact of irrigated agricultural activity is large and pervasive in the State's economy as reported in the report of the University of California Agricultural Issues Task Force 1978, entitled "Agricultural Policy Challenges for California in the 1980's", published by the Division of Agricultural Sciences, University of California, October 1978.

> "Agriculture's impact on California involves much more than the physical presence of farms, ranches and food processing plants. Agriculture directly affects every Californian daily through the availability, cost and nutritional quality of food. The economic and social health of agriculture strongly influences most of the entire state. No other economic sector occupies so much land, uses so many natural resources, involves so many people, and yet seems to be so much taken for granted."

Many commodities produced in California are only possible because of the State's unique climate and location. There are few, if any, areas of similar size in the world with such diverse topography and climate where natural forces have been so extensively harnessed for agricultural production. The State's climate is suitable for growing over 200 commercial varieties of crops. It leads the nation in the production of 44 of them.

Other commodities are produced in California because the State is somewhat isolated geographically. Milk, eggs, poultry, livestock and feed grains have been produced for local consumption as a result of this isolation from other areas of the nation where such products are extensively produced. In addition, this geographic isolation has enabled California agriculture to attempt many innovative marketing programs, in the form of marketing orders and agreements, that are not practicable in other areas of the United States.

Agricultural products of the southern San Joaquin Valley represent more than one-third of the total value of the State's agricultural production. Therefore, any consideration of regulations or programs which would affect the water supplies avaiable to, or planned for, the area, including local surface and underground water and imported supplemental water, to meet the needs of irrigated agriculture must include full consideration of economic, social and human impacts. This chapter is a brief overview of the economic importance of irrigated agriculture in California and in the southern San Joaquin Valley.

Economic Characteristics of California's Agriculture

California agriculture is recognized as a leader not only nationally, but also throughout the world. Many innovative improvements in agricultural practices which have been adopted nationally and throughout the world were developed, and continue to be developed, in California. This has provided, and continues to provide, California agriculture with a competitive advantage over other areas.

While California's climate has been conducive to growing a wide variety of commodities, it also has made it a pleasing place to live, a fact that has caused increasing problems for California agriculture. Rapid growth of population and industry have resulted in accompanying pressures on the agricultural economy. Hundreds of thousands of acres of productive farm land have been lost to urban development in the last half-century and the process of encroachment continues. In recent years, about 20,000 acres of irrigated land per year have been converted to urban uses. New irrigated acreage has been brought into production, but at higher costs. Urban pressures also have caused land values and taxes to increase in remaining agricultural areas so that many farmers are having difficulty in maintaining an economic return.

California's "Top Twenty" crop and livestock commodities account for about 80 percent of the State's

gross farm income. In 1977, dairy products, cattle and calves, and eggs continued to dominate the livestock industry, while cotton, grapes, hay, processing tomatoes and lettuce were the most important crops.

California's commercial agriculture probably is the most diversified in the world, with no one crop dominating the State's farm economy. This is illustrated by the fact that all but two crops individually account for less than five percent of the State's total gross farm income. The ranking and value of the 20 leading farm products in California in 1977 are shown in Table 20.

TABLE 20
LEADING FARM PRODUCTS IN CALIFORNIA IN 1977

Farm Product	Commodity Ranking	Value 1/	Percentage of State Total
		-1,000 dollars-	-Percent-
Milk & Cream	1	1,180,840	12.7
Cattle & Calves	2	987,706	10.6
Cotton	3	816,228	8.8
Grapes	4	705,145	7.6
Hay	5	456,011	4.9
Tomatoes, Processing	6	426,184	4.6
Eggs, Chicken	7	353,272	3.8
Lettuce	8	304,952	3.3
Nursery Products	9	297,390	3.2
Flowers & Foliage	10	273,475	2.9
Almonds	11	267,750	2.9
Strawberries	12	168,362	1.8
Rice	13	167,666	1.8
Oranges	14	160,410	1.7
Tomatoes, Fresh Mkt	15	153,961	1.7
Walnuts	16	147,810	1.6
Peaches	17	139,398	1.5
Chickens	18	138,405	1.4
Sugar Beets	19	126,381	1.4
Potatoes	20	124,943	1.3

1/ Based on value of quantity harvested for crops and on value of quantity marketed for livestock and poultry products.

Source: State Department of Food and Agriculture's report on "California Principal Crop and Livestock Commodities, 1977", p. 14.

The 20 leading agricultural counties in California in terms of 1977 values are indicated in Table 21.

TABLE 21
LEADING AGRICULTURAL COUNTIES IN CALIFORNIA IN 1977

County	Value of Farm Products (1,000 dollars)
Fresno	1,096,071
Kern	799,043
Tulare	734,755
San Joaquin	520,475
Merced	506,770
Stanislaus	500,042
Monterey	498,466
Riverside	494,922
Imperial	437,160
Kings	387,884
Ventura	377,838
San Bernardino	354,037
San Diego	335,035
Madera	219,640
Sutter	200,878
Los Angeles	200,165
Santa Barbara	190,808
Yolo	189,972
Orange	168,762
Butte	143,691

Source: Ibid, p. 16

The 1977 acreages by principal crop groupings were: field crops, 6,531,000; fruit and nut crops, 1,674,000; and vegetables and melons, 987,000; for a total of 9.2 million acres. Acreages of the 10 principal crops are listed following:

Crop	Acres
Cotton	1,390,000
Alfalfa	1,140,000
Barley	950,000
Wheat	678,000
Grapes	622,000
Rice	308,000
Tomatoes	276,000
Almonds	273,000
Oranges	187,000
Walnuts	176,000
Total	6,000,000

California leads the nation by a wide margin in the production of fruits, nuts and vegetables. The State accounts for over 40 percent of the nation's cash farm receipts for fruits and nuts and about one-third for vegetables.

The United States exports more agricultural products than any other country and is one of the few positive influences in the balance of payments. About one in every three acres of American cropland produces for export, and last year about one-fourth of the total farm cash receipts

came from world markets. (from *Ag World*, October 1978 issue, p. 1.).

A large amount of California's agricultural commodities are sold in international markets. The total value of exports of agricultural products in FY 1976-77 was $2.36 billion, as compared with $1.86 billion in FY 1975-76. During this same period, California's share of the Nation's total agricultural exports rose from 8.3 percent in FY 1975-76 to 9.5 percent in FY 1976-77. Five commodity groups account for nearly half of the value of the State's total exports, and 15 account for two-thirds of the total, as indicated by data in Table 22.

TABLE 22

CALIFORNIA'S LEADING AGRICULTURAL EXPORT COMMODITY GROUPS VALUED AT PORT OF EXPORTATION

Fiscal Years 1976 and 1977

[1,000 dollars]

Export Commodity	1975-76 Values	1976-77 Values
Cotton lint	402,323	640,927
Wheat	221,471	157,446
Almonds	95,908	119,561
Grapes	107,762	108,075
Oranges	97,231	103,409
Subtotals	924,695	1,129,418
Rice	81,545	81,679
Lemons	73,904	79,077
Prunes and Plums	54,481	46,789
Walnuts	38,662	43,975
Cattle products (excluding dairy)	29,898	39,892
Cottonseed	36,800	38,308
Tomatoes and tomato products	34,324	31,330
Peaches	25,878	30,047
Alfalfa	16,617	29,085
Lettuce	23,694	25,081
Subtotals	415,803	445,263
Subtotals for all 15	1,340,498	1,574,681
All Other Commodities	522,371	784,787
Total All Commodities	1,862,869	2,359,468

Source: California Crop and Livestock Reporting Service, April 1978 report on "Exports of Agricultural Commodities Grown or Produced in California, Fiscal Year 1976 and 1977", p. 4.

Cotton continues to lead in exports and about three-fourths of the 1976 California cotton crop was exported in FY 1976-77. About two-thirds was exported from the Los Angeles Customs District, with San Francisco accounting for most of the remainder. Also, about two-thirds (in value) of the State's wheat crop and about three-fifths of the almond crop were exported.

Nationally, some of California's more important exports also dominate. Some of these products and their share of the Nation's exports are: cotton, about 40 percent; cottonseed oil, about 25 percent; brown rice, about 85 percent; almonds, 100 percent; dates and figs, 100 percent; grapes, 95 percent; lemons, 90 percent; prunes, 95 percent; fresh oranges, 80 percent; and walnuts, 99 percent.

Economic Importance of California's Agriculture

The economic effect on California's economy of the production, processing and marketing of agricultural commodities, having a value of over $9 billion, is enormous. It is in the order of three to one, or $27 billion. That is to say, an additional $18 billion in business activity results from the handling, processing, storing and other marketing functions performed on the $9 billion worth of commodities.

Nationwide, the farmer receives about 40 cents of each dollar spent by the consumer at the retail store for food. As can be observed, this is a ratio of 2.5:1.0. The ratio will vary depending upon the marketing functions performed on the particular commodity. However, this ratio, while showing a value added, does not indicate what happens to the economy as a result of this agribusiness.

So-called "input-output" (I-O) analysis is used to measure the total effect of agribusiness on the economy. It is essentially a description of the relationship between industries within an economy. Expressed another way, it describes the interdependence among the various sectors of the economy as they combine to meet a given demand for goods and services. It shows all transactions of individual enterprises with other firms, at a point in time, with the inputs being what a firm buys, and outputs, what it sells. It is called "input-output" because it shows how much each sector of the economy buys from and sells to each other. For example, for each dollar increase (or decrease) in crop production, the analysis shows all of the sectors affected up to the final demand.

What do such analyses indicate for agriculture in California? The DWR has recently completed an updated I-O analysis of the California economy as of the year 1976. It is believed to be the most comprehensive of any of such models made for California. It breaks down the economy into 157 sectors, of which 34 are sectors within agriculture. Data calculated for the most important sectors within California agriculture (those in which 1976 gross farm sales value exceeded $100 million) indicate the following ratios (or gross output multipliers) of farm income to the total income resulting in the overall economy from production and marketing in the sectors indicated:

Dairies	2.7
Poultry and Eggs	2.7
Cattle and Calves	2.6
Cotton	3.4
Wheat	2.8
Rice	2.8
Barley	2.9
Corn	2.8
Hay and Pasture	2.9
Walnuts	3.2
Almonds	3.2
Non-citrus fruits	3.2
Citrus fruits	3.3
Vegetables	3.0
Melons	3.0
Sugar Beets	2.9
Greenhouse and Nursery	3.1

The foregoing approximates, in the aggregate, the multiplier ratio of 3 to 1 mentioned previously. The higher the ratio, (e.g., cotton, 3.4:1.0) the greater is the impact on the economy.

The 3 to 1 gross output multiplier is consistent with previous I-O models made for the California region and is widely used in professional circles. On occasion, reference is made to ratios of 4 to 1 or even 5 to 1. This may be caused by some double counting of business-generated activity, or where subsequent "rippling" effects are included, which do occur, but which should not be uniquely attributable to the particular agribusiness activity being measured.

Economics of Agriculture in the Southern San Joaquin Valley

The five counties in the southern San Joaquin Valley provide a large percentage of the quantity and value of crops and livestock produced in California. Fresno, Kern, and Tulare counties are the number one, two, and three counties, respectively in value of agricultural production in the State. Kings County is number 10 and Madera County is number 14. Not only does Fresno County lead all other counties in California, it is also the number one county in the nation in crops and livestock value. It even exceeds the individual output of 40 percent of the other states. Kern and Tulare counties are also among the top five counties in the nation. The 1977 acreages and crop values for the southern San Joaquin Valley are shown in Table 23.

The 3,660,000 harvested acres as reported by the County Agricultural Commissioners comprise essentially the irrigated area, as dryland acreage was not included. Also, a reduction of 50,000 acres from the Kern County data was made to reflect crop acres not in the Valley portion of the County. Irrigated acreage in the five counties approximates 40 percent of the State's total.

In terms of acreage and value, principal crops, as reported in the annual County Agricultural Commissioners' reports, are shown in Table 24.

TABLE 23
CROP ACREAGE AND VALUE IN SOUTHERN SAN JOAQUIN VALLEY COUNTIES IN 1977

County	1977 Value ($1,000)	1977 Acreage (1,000's)	Value per Acre ($/ac)
Madera	219,640	299	735
Fresno	1,096,071	1,200	913
Kings	387,884	605	641
Tulare	734,755	626	1,174
Kern	799,043	930	859
Total	3,237,393	3,660	885 (average)

TABLE 24
PRINCIPAL CROP ACREAGES AND VALUES IN SOUTHERN SAN JOAQUIN VALLEY COUNTIES IN 1977

County and Crop	1977 Acreages	Crop Values ($ million)
Madera		
grapes	55,000	71
cotton	59,000	29
alfalfa hay	51,000	21
almonds	13,000	14
irrigated pasture	42,000	4
wheat and barley	40,000	7
Fresno		
grapes	193,000	265
cotton	329,000	194
tomatoes	39,000	56
barley	233,000	43
oranges	20,000	36
alfalfa hay	85,000	34
Kings		
cotton	221,000	139
barley	147,000	32
alfalfa hay	60,000	24
wheat	39,000	11
alfalfa seed	12,000	9
safflower	29,000	9
Tulare		
grapes	74,000	158
cotton	210,000	120
oranges	83,000	75
plums	11,000	31
walnuts	24,000	21
alfalfa hay	52,000	21
Kern		
cotton	344,000	220
grapes	73,000	134
potatoes	29,000	54
alfalfa hay	115,000	43
citrus	24,000	35
carrots	9,000	34

The diversity of major crops in the southern San Joaquin Valley provides a stability to the region, a risk

aversion situation that only a highly sophisticated irrigated agriculture can provide.

With an annual gross crop value averaging currently about $3.3 billion for the five-county area and with a multiplier factor of three, the agribusiness value to the State is about $10 billion. For the region, of course, the overall effect is less because some of the induced and indirect effects occur outside of the region.

The regional economic effect of agriculture is estimated at about 2.2 to 1 based on I-O studies made by the University of California Agricultural Cooperative Extension Service. A study made for Colusa County in 1973 indicates about 2.25 and another made for Westlands Water District and Fresno County in 1977 indicates about 2.15. The direct and indirect sector multipliers derived from the Fresno County study were as follows:

Cotton lint and seed	2.3
Sugar Beets	2.2
Irrigated pasture	2.0
Cannery tomatoes	2.3
Grapes	2.2

The regional economy of the southern San Joaquin Valley amounts to about $7.1 billion (about 2.2 times the gross crop value) and is dominated by agricultural production and related activities. These activities include: construction; meat, poultry and dairy processing; grain milling; cotton ginning; processing of animal feeds; fruit and vegetable processing; printing and publishing; chemicals; transportation; communications; utilities; finance of other services and household retailing.

As indicated by the foregoing economic data, any reduction in agricultural production will have a double to triple depressive impact on the economy of the region and the State. Also, if agricultural production is not allowed to increase, there will be a continuing future loss to the economy of the State and the region. This poses serious economic questions for the State as it deals with agricultural, water and other resource policy issues.

Significance of Irrigation

Irrigated agriculture provides an economic stability to a region's economy that cannot be matched in rain-supplied agriculture. As compared with the latter, irrigated farming provides much greater uniformity of quality and quantity of output; allows a wider variety of crops; can respond more readily to changes in market demand for crops; and makes possible a surpassing yield per acre of commodity and intensity of land use. Irrigated agriculture has made California the number one farm state for over 25 years and now accounts for 9.5 percent of the Nation's cash receipts from farming. Irrigated agriculture supports the "ever normal granary" or food bank concept which can protect the Nation from vagaries of weather, which periodically affect rain-fed agricultural regions, or from the vagaries in agricultural import policies of foreign governments.

Benefits of irrigated agriculture are often illustrated dramatically. During 1971-72, the principal agricultural producing regions of California experienced 45 percent of average precipitation, yet agriculture in the aggregate was little affected. One year later, 1972-73, the same areas received about 45 percent above normal precipitation, yet again agriculture was little affected. But more profoundly, during the unprecendented "back to back" drought years of 1976 and 1977, when precipitation in the northern two-thirds of the State was less than half of normal, agricultural production set new records of income. The availability of ground water was a major factor in achieving this result.

Photo Courtesy Don Patrick Higgins

Cotton gins prepare San Joaquin Valley cotton for domestic and foreign textile markets.

CHAPTER VIII

THE FUTURE OF THE SOUTHERN SAN JOAQUIN VALLEY

Elimination of the ground water overdraft in the souhern San Joaquin Valley is a matter of great urgency and importance, not only to affected landowners and water districts, but also to agriculturally related industries, including suppliers, processors, communities and farm workers. The problem also continues to receive the attention of the State and Federal governments and environmental groups. However, there is no common support for a given course of action to correct the overdraft.

As has been pointed out, further agricultural development of the Valley can be expected to occur on irrigable lands overlying usable ground water. The area overlying usable ground water comprises 3,900,000 acres of which only 12-1/2 percent, or 490,000 acres, of irrigable lands remain undeveloped. The better lands in the Valley have, for the most part, been developed. With favorable economic conditions, it appears reasonable that as many as 220,000 acres of additional land could be put under irrigation with ground water in the next 20 years. Under these conditions, and with completion of SWP facilities to deliver full contractual water entitlements in the Valley, the overdraft would be increased from the present value of 1.4 million acre-feet per year to about 1.7 million acre-feet by year 2000. This estimate provides allowance for reasonable urban growth and also for necessary disposal of brackish drainage waters.

The solution to the overdraft problem in the southern San Joaquin Valley rests largely with State and Federal administrative, legislative, and judicial institutions, either as active participants in project construction or in the performance of their statutory functions.

With respect to local action, more conservative water use has been suggested as a partial solution to the problem. Little opportunity for this exists on a Valley-wide basis. The Tulare Basin, which includes most of the southern San Joaquin Valley, exhibits an overall water use efficiency of 96 percent. Expressed in another way, only four percent of the total water supply of the Basin is not consumptively used for beneficial purposes. This minor quantity consists of irrecoverable waste and drainage waters and evaporation from ponded areas in the Valley floor.

At the farm level, water applied in excess of the consumptive use of the crops throughout most of the Valley returns to ground water storage for subsequent reuse. The term "excess" should not be considered as synonymous with waste, since water in addition to consumptive use is required in the irrigation process to physically meet the consumptive requirement and to provide necessary leaching of salts through the soil profile.

With certain high-revenue crops, sprinklers, drip irrigation systems and other devices can be economically employed to reduce net water use. With respect to reducing total water needs, the possibilities for water savings to the basin through such application procedures are generally limited to areas that do not overlie ground water or where percolation in excess of the salt leaching requirement adds to the quantity of brackish waste water.

A reduction in net water use could be effected by changes in crop patterns. Conversion to production of grains or other crops, which have minimum water requirements and generally have lower market values, could achieve some savings. However, present cropping patterns have been established in response to market demand, and investments, including financial obligations for water supply facilities, have been made on that basis. A change to crops with lower water requirements and lower values could seriously affect the farmers' ability to meet fixed financial obligations already incurred.

In summary, although some amount of "stretching" of water supplies might be accomplished, little opportunity exists for any measurable reduction in the existing overdraft by this means. In general, the cost of water is now such a significant part of the farmers' budget that farm irrigation operations are carried on with a high degree of efficiency for economic reasons.

Thus, it is the availability or nonavailability of sufficient supplemental water which will dictate the future of the Valley. Depending upon actions (or inaction) of responsible State and Federal institutions, one of the three future scenarios discussed in the following sections may be expected to result.

Scenario No. 1 — Removal of Land from Production

Removal from production of about 600,000 acres of land presently irrigated from ground water would reduce the net use of ground water in the Valley by about 1.4 million acre-feet, or the amount of the present overdraft. This scenario could occur with enactment and implementation of legislation proposed by the Governor's Commission to Review California Water Rights Law. The policy regarding elimination of overdraft in the proposed legislation is as follows:

"15002. It is the policy of the Legislature that ground water resources shall be managed to avoid any waste or unreasonable use, unreasonable method of use

or unreasonable method of extraction of groundwater; that groundwater resources shall be managed to avoid conditions of long-term overdraft, water quality and other significant environmental degradation, and subsidence except where local groundwater management authorities can justify their occurrence; that where conditions of long-term overdraft, water quality and other significant environmental degradation, or subsidence now exist, groundwater resources shall be managed to prevent further aggravation of those conditions and programs shall be implemented to eliminate them wherever practical, except where local groundwater management authorities justify their continuance; and that groundwater resources shall be managed to use groundwater and surface water resources conjunctively wherever practical.

The Legislature, however, recognizes that in certain areas overdraft cannot presently be eliminated without causing severe economic losses and hardship. In such areas, groundwater management programs provided for in this part shall include all reasonable measures to prevent further increase in the amount of overdraft, and wherever practical shall also include any measures reasonably available to reduce overdraft.''

The proposed legislation provides an administrative procedure whereby, pursuant to the quoted policy, management programs would be developed locally to eliminate overdraft, subject to review by SWRCB. If the plans are found not to conform to the policy, SWRCB is empowered to seek judicial action through the Attorney General to limit ground water extractions through adjudication. Without an adequate supply of supplemental water, elimination of overdraft in the southern San Joaquin Valley, under this procedure, would require removal of about 600,000 acres of land from irrigated agricultural production.

The economy of California and of the region would be severely impacted by such an occurrence. The 600,000 acres amounts to about six percent of the irrigated land in California and about 18 percent of that in the southern San Joaquin Valley. It is estimated that the value of the direct loss would be about $530 million annually, while the impact on the State's economy would be a loss of about $1.6 billion annually. The regional impact on the Valley is estimated to be in the order of $1.1 billion annually. A quantitative assessment has not been made of the social and human effects resulting from the foreclosed businesses. Neither have estimates been made of other community costs such as unemployment, or reduction of tax base and their effects on the economy.

Implementation of such a program would face almost insurmountable difficulties. Any precise delineation of ''areas of overdraft'' in the San Joaquin Valley is virtually impossible, inasmuch as topographic, geologic or hydrologic boundaries in existence are not sufficiently definitive. The question of which lands would be removed from production also poses seemingly insurmountable problems, which could only be resolved through massive adjudications of ground water rights. Under this scenario, increased development in the San Joaquin Valley would not be permitted regardless of any motivation for development from increasing demands for food and fiber throughout the world. The incentive for further water development to enhance California's economy through the agricultural sector, both in the area overlying ground water and in presently irrigable undeveloped lands on the margins of the Valley, would be lost.

It is to be noted that no ground water basin in California has been adjudicated and no restrictions on the pumpage of ground water have been subsequently instituted, without the availability of an adequate supply of supplemental water to maintain the level of total water use existing prior to the adjudication and imposition of the restrictions.

Scenario No. 2 — Continuation of Unmitigated Overdraft

The economic consequences of continued unmitigated overdraft would also be severe although such adverse consequences would develop gradually in reaction to economic factors, and without the immediate mandated impact of Scenario No. 1.

Ground water levels would continue to decline as a result of overdraft created by presently irrigated land. Under favorable economic conditions, this decline could be accelerated with the development of an additional 220,000 acres, as might occur by year 2000.

The vast underground reservoir in the southern San Joaquin Valley, now containing a usable water supply estimated at about 150 million acre-feet, within 500 feet of the ground surface, would continue to meet overlying demands, but at increasing cost. Deepening of wells and extension of pumping equipment would follow the declining water table, and ever-increasing energy consumption and attendant costs for pumping would be experienced.

Eventually, the increased costs would force lands out of production and this would continue until an equilibrium of water supply and use was achieved. Such a condition would probably not be established until well after the turn of the century. At that time, lands being irrigated from ground water, under conditions of hydrologic equilibrium, would be pumping from depths far greater than those of today and would have a built-in increment of fixed cost for ground water pumping thereafter. Human and social costs similar to Scenario No. 1 would take place, but over a longer period of time.

Land subsidence would continue and community costs would be incurred in certain areas to repair the effects on surface facilities. There would be no irreparable damage to the ground water basin through loss of storage or conveyance capacity, since the compaction occurs primarily

in the clay lenses which, though saturated, do not constitute the water-bearing aquifers used in storage and cyclic regulation. The effect of subsidence on the ground water basin in the San Joaquin Valley has been described in studies made by the U. S. Geological Survey and reported at the 11th Biennial Ground Water Conference in Fresno, September 1977. That document, "Changes in Aquifer-System Properties with Groundwater Depletion", authored by Ben E. Lofgren, states:

> "Nonrecoverable compaction occurs principally in the fine-grained, slow-draining interbeds of the aquifer system. *No measurable change in transmissivity, storage characteristics, or rechargeability of the coarse-grained aquifers has been detected at the sites studied.* The significant change during the first cycle of water-level decline, therefore, is a one-time release of interstitial water from the slow-draining aquitards. Less than 5 percent of this water of compaction returns to the interstitial voids of the aquitard when water levels recover". (Emphasis supplied).

Under this scenario, while there would be an eventual significant loss of irrigated acreage, there would continue to be a positive contribution to the State's economy from the production of the area, for a substantial period of time, but the contribution would steadily decrease as lands were removed from production.

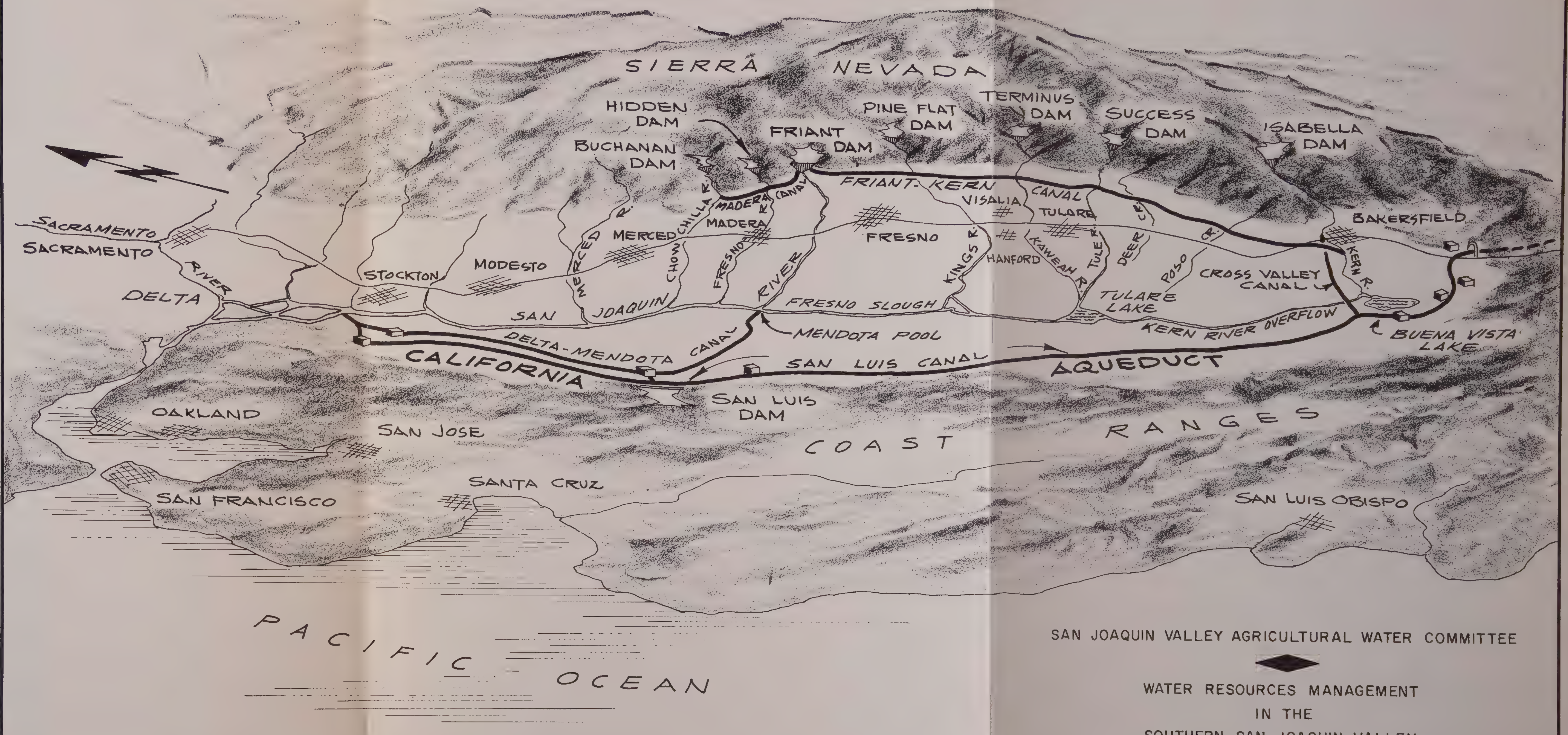
Scenario No. 3 — Provision for an Adequate Supply of Supplemental Water

The development and delivery of sufficient water for the southern San Joaquin Valley, to overcome present overdraft and provide for nominal projected growth, provides the only means of avoiding severe adverse economic impacts. As has been demonstrated, the physical and institutional management tools needed to integrate additional supplies of supplemental water into ongoing conjunctive-use programs, now exist throughout nearly 90 percent of the area overlying usable ground water in the Valley. The history of the San Joaquin Valley shows that the remaining area will organize and also establish these tools, at such time as supplemental water becomes a reality. There are public water districts now in existence, without supplemental water, looking to the Mid-Valley Canal for such supplies.

It is recognized that the incremental cost of supplemental water will be greater than the cost of pumping from the overdrawn ground water supply. Financial programs, which could be established under existing statutory authority by existing and newly created management entities, where necessary, would be required to meld the cost of the more expensive supplemental water supplies with that of existing supplies. The supplemental water would be marketed for use in lieu of ground water. This would be done under programs of economic inducement, achieved by establishment of appropriate rate structures for surface water together with the levying of taxes, assessments, or other charges. Such programs have been successfully employed by Valley management entities in integrating more than 3.0 million acre-feet of CVP and SWP water into their conjunctive-use operations.

Under this scenario, the economic productivity of the Valley would be preserved and enhanced. A condition of hydrologic equilibrium would be established with stabilization of ground water levels and cessation of the increase in energy consumption for pumping. This is the scenario envisioned in The California Water Plan — the basis of the present water policy of the State of California, as set forth in the Water Code.

PLATES

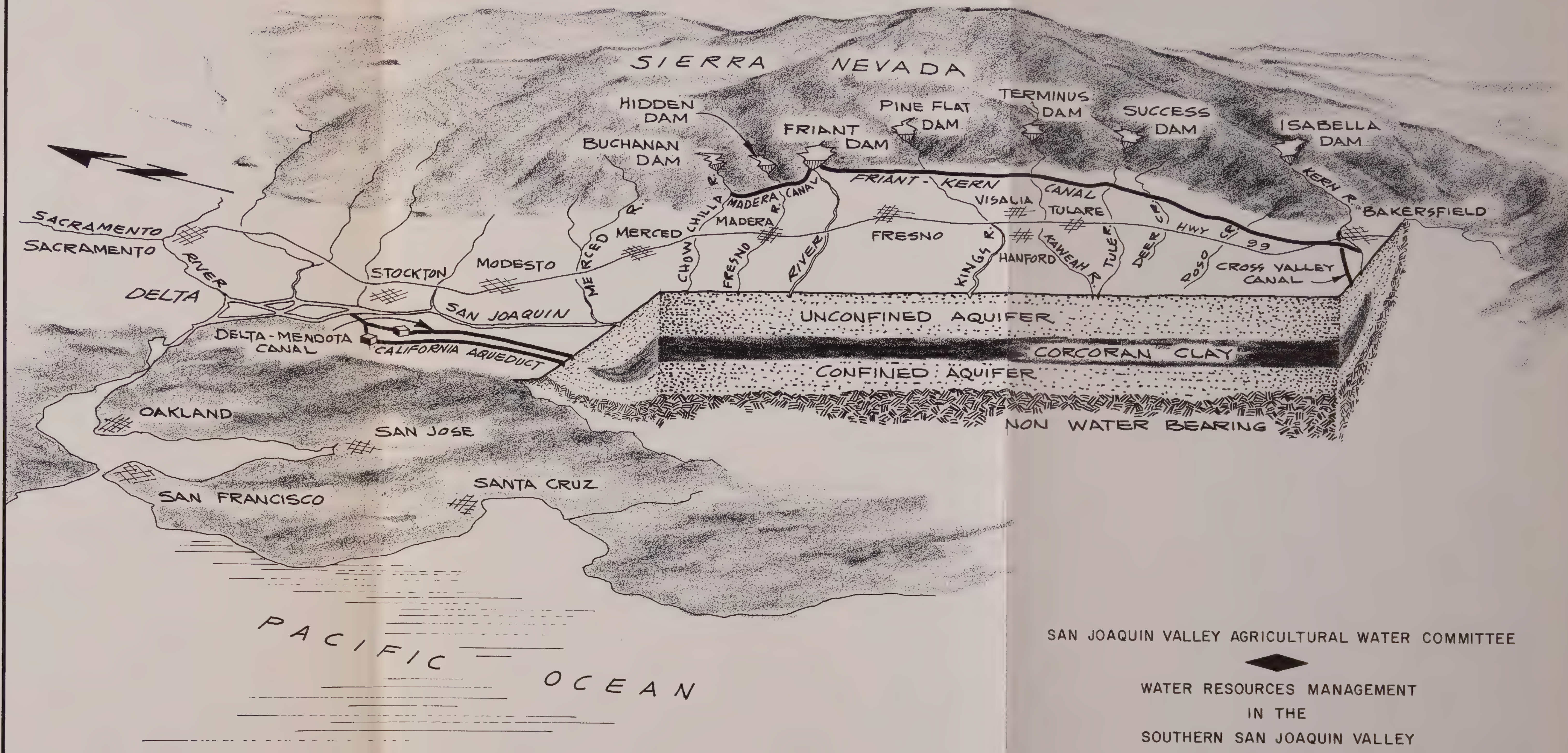


SAN JOAQUIN VALLEY AGRICULTURAL WATER COMMITTEE

WATER RESOURCES MANAGEMENT
IN THE
SOUTHERN SAN JOAQUIN VALLEY

PRINCIPAL SURFACE WATER SUPPLY FEATURES

BOOKMAN — EDMONSTON ENGINEERING, INC.
JANUARY 1979



SAN JOAQUIN VALLEY AGRICULTURAL WATER COMMITTEE

WATER RESOURCES MANAGEMENT
IN THE
SOUTHERN SAN JOAQUIN VALLEY

DIAGRAMMATIC PROFILE OF THE GROUND WATER BASIN

BOOKMAN - EDMONSTON ENGINEERING, INC.

JANUARY 1979

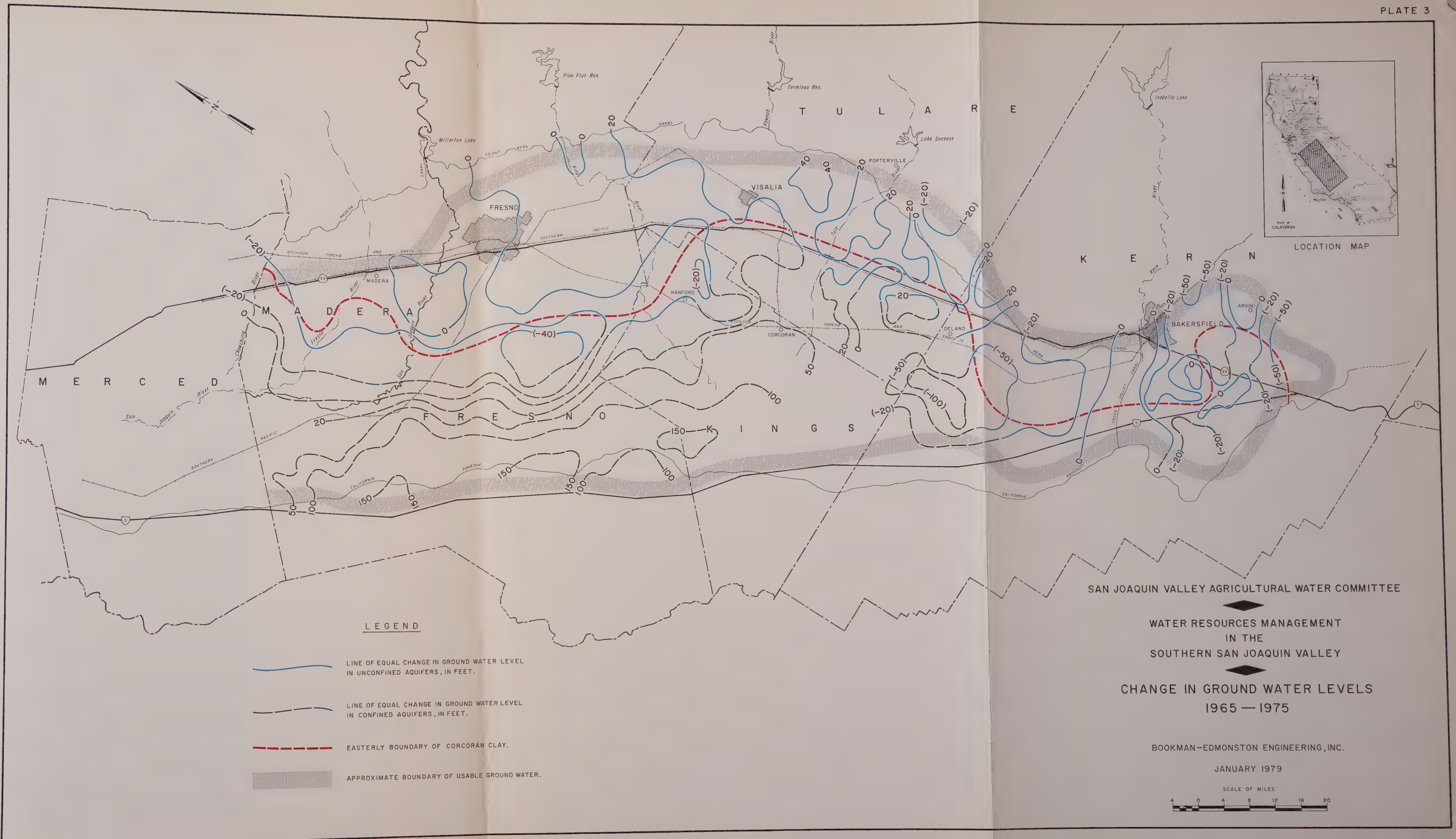

SAN JOAQUIN VALLEY AGRICULTURAL WATER COMMITTEE
WATER RESOURCES MANAGEMENT IN THE SOUTHERN SAN JOAQUIN VALLEY
CHANGE IN GROUND WATER LEVELS 1965 — 1975
BOOKMAN–EDMONSTON ENGINEERING, INC.
JANUARY 1979
SCALE OF MILES
4 0 4 8 12 16 20
LEGEND
LINE OF EQUAL CHANGE IN GROUND WATER LEVEL IN UNCONFINED AQUIFERS, IN FEET.
LINE OF EQUAL CHANGE IN GROUND WATER LEVEL IN CONFINED AQUIFERS, IN FEET.
EASTERLY BOUNDARY OF CORCORAN CLAY.
APPROXIMATE BOUNDARY OF USABLE GROUND WATER.
LOCATION MAP
STATE OF CALIFORNIA
N
M E R C E D
M A D E R A
F R E S N O
K I N G S
T U L A R E
K E R N
FRESNO
MADERA
VISALIA
HANFORD
CORCORAN
PORTERVILLE
DELANO
BAKERSFIELD
ARVIN
Millerton Lake
Pine Flat Res.
Terminous Res.
Lake Success
Isabella Lake
FRIANT KERN CANAL
CALIFORNIA AQUEDUCT
SOUTHERN PACIFIC
ATCHISON TOPEKA AND SANTA FE
CROSS VALLEY CANAL
San Joaquin River
Kings River
Kern River
Tule River
Kaweah River
Chowchilla River
Fresno River

PLATE 4

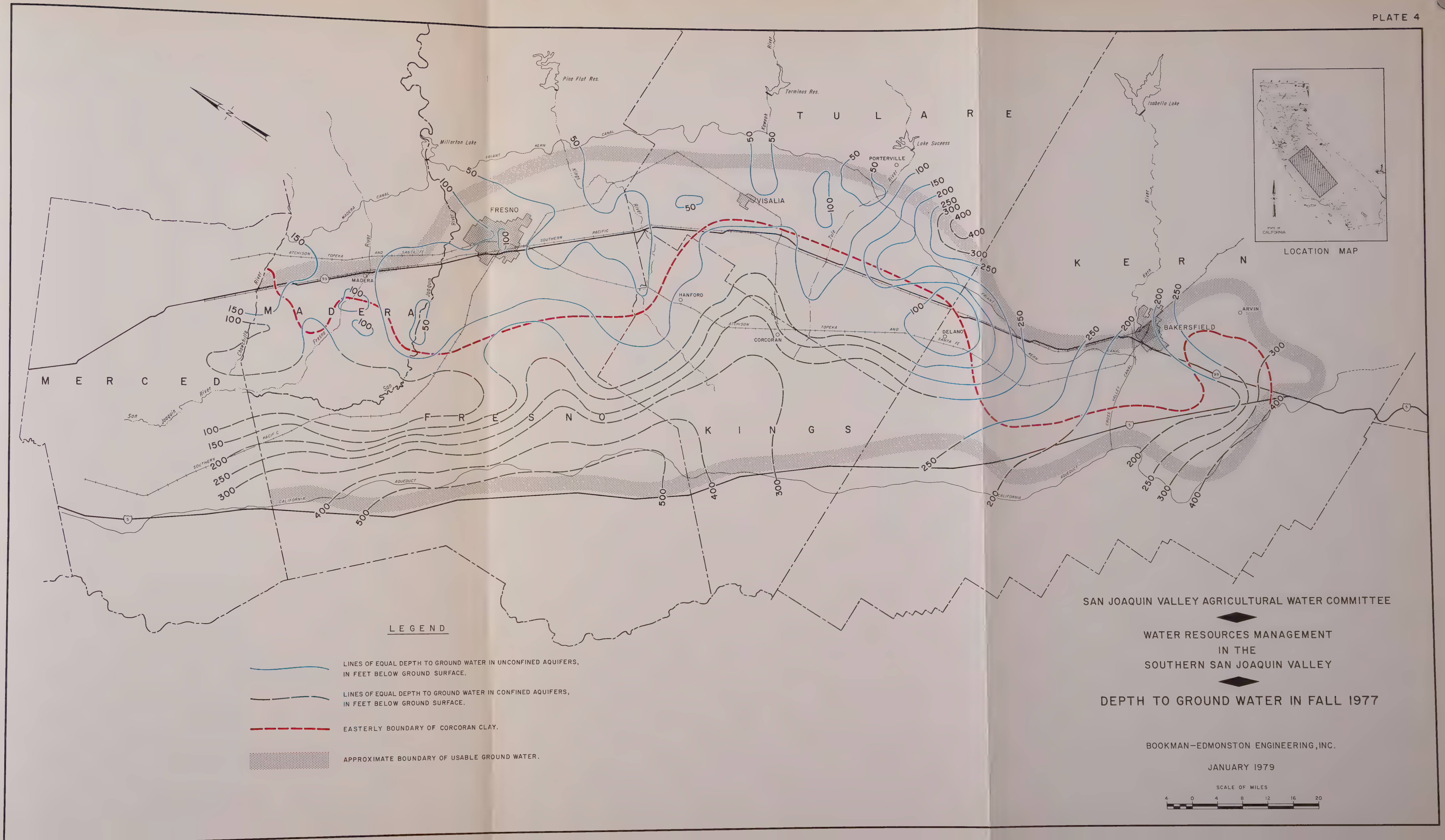
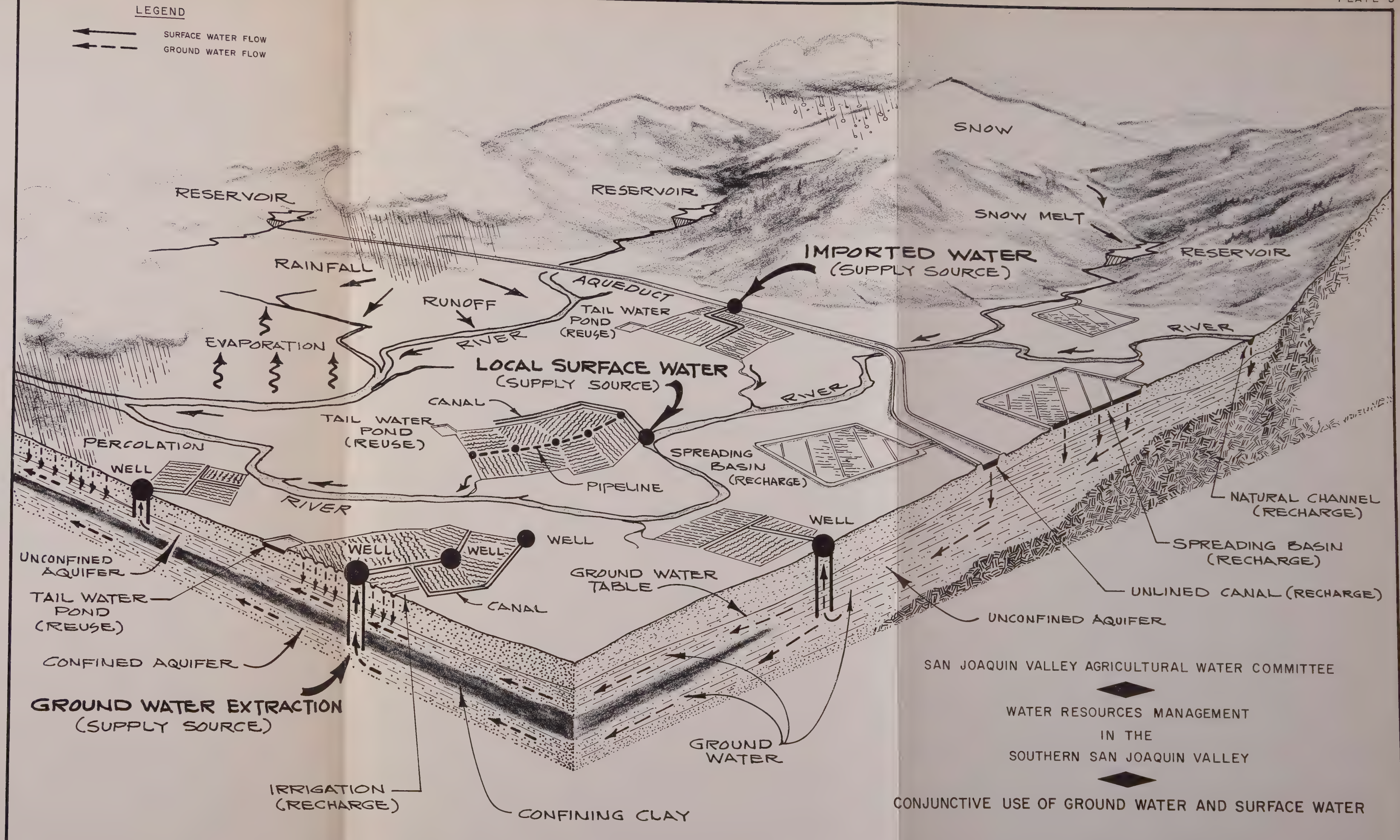

SAN JOAQUIN VALLEY AGRICULTURAL WATER COMMITTEE
WATER RESOURCES MANAGEMENT
IN THE
SOUTHERN SAN JOAQUIN VALLEY
DEPTH TO GROUND WATER IN FALL 1977
BOOKMAN–EDMONSTON ENGINEERING, INC.
JANUARY 1979
SCALE OF MILES
4 0 4 8 12 16 20
LEGEND
LINES OF EQUAL DEPTH TO GROUND WATER IN UNCONFINED AQUIFERS, IN FEET BELOW GROUND SURFACE.
LINES OF EQUAL DEPTH TO GROUND WATER IN CONFINED AQUIFERS, IN FEET BELOW GROUND SURFACE.
EASTERLY BOUNDARY OF CORCORAN CLAY.
APPROXIMATE BOUNDARY OF USABLE GROUND WATER.
LOCATION MAP
MERCED
MADERA
FRESNO
KINGS
TULARE
KERN
FRESNO
MADERA
HANFORD
CORCORAN
VISALIA
PORTERVILLE
DELANO
BAKERSFIELD
ARVIN
Millerton Lake
Pine Flat Res.
Terminus Res.
Lake Success
Isabella Lake
ATCHISON TOPEKA AND SANTA FE
SOUTHERN PACIFIC
CALIFORNIA AQUEDUCT
FRIANT KERN CANAL
CROSS VALLEY CANAL
San Joaquin River
Kings River
Kern River

PLATE 5



SAN JOAQUIN VALLEY AGRICULTURAL WATER COMMITTEE

WATER RESOURCES MANAGEMENT
IN THE
SOUTHERN SAN JOAQUIN VALLEY

CONJUNCTIVE USE OF GROUND WATER AND SURFACE WATER

BOOKMAN - EDMONSTON ENGINEERING, INC.
JANUARY 1979

LEGEND

APPROXIMATE BOUNDARY OF USABLE GROUND WATER.

MANAGED AREAS WITH CONJUNCTIVE USE PROGRAMS

ORGANIZED AREAS WITH MINOR OR NO USE OF GROUND WATER.

ORGANIZED AREAS WITHOUT SUPPLEMENTAL SURFACE WATER.

UNORGANIZED AREAS.

NOTE

KERN COUNTY WATER AGENCY (NOT SHOWN) INCLUDES THE SAN JOAQUIN VALLEY PORTION OF KERN COUNTY.

NOTE:
ADAPTED FROM STATE OF CALIFORNIA DEPARTMENT OF WATER RESOURCES MAP, ENTITLED "BOUNDARIES OF PUBLIC WATER AGENCIES — SAN JOAQUIN VALLEY", DATED JULY 1978.

SAN JOAQUIN VALLEY AGRICULTURAL WATER COMMITTEE

WATER RESOURCES MANAGEMENT
IN THE
SOUTHERN SAN JOAQUIN VALLEY

GROUND WATER MANAGEMENT ENTITIES

BOOKMAN—EDMONSTON ENGINEERING, INC.

JANUARY 1979

SCALE OF MILES
4 0 4 8 12 16 20

TABLES A-1 and A-2

TABLE A-1

SUMMARY OF STATISTICAL DATA FOR ENTITIES ENGAGED IN GROUND WATER MANAGEMENT IN THE SOUTHERN SAN JOAQUIN VALLEY

Management Entity	Date of Formation	Area in Acres			Local Surface Water		Imported Water		Estimated Gross Ground Water Extraction (Af/yr)	Project Facilities			Project Capital Investment	Annual Operating Budget	Comments
		Gross	Irrigable	Irrigated	Source	Amount (Af/yr)	Source	Amount (Af/yr)		Pipelines (Miles)	Canals (Miles)	Recharge Basins (Acres)			
MADERA COUNTY															
CHOWCHILLA WATER DISTRICT	1949	64,900	58,200	52,600			Madera Canal Class 1 Class 2 Average	55,000 160,000 135,000	40,000	60	134-U	25	$3,000,000	Not Avail.	16% of Class 2 amount assigned to La Branza W.D.
MADERA IRRIGATION DISTRICT	1920	114,000	106,000	89,300	Willow Creek Big Creek Fresno River	40,000	Madera Canal Class 1 Class 2 Average	85,000 186,000 178,000	80,000	60	320-U	407	14,200,000	$2,700,000	Has contract with U.S.G.S. for the development of a digital ground water model.
FRESNO COUNTY															
CONSOLIDATED IRRIGATION DISTRICT	1921	150,500	139,700	137,200	Kings River	270,000	Friant-Kern Canal Class 2 (Average)	41,000	220,000	130	370-U	1,500	Not Avail.	Not Avail.	Short-term contract with U.S.B.R. for surplus Friant-Kern Canal water. District owns or has easements for 1500 Acres of recharge basins.
CRESCENT CANAL COMPANY	Not Avail.	20,000	18,000	18,000	Kings River	20,200			36,000		25-U		Not Avail.	Not Avail.	Subsurface conditions preclude artificial recharge.
FRESNO, CITY OF							Friant-Kern Canal Class 1 Average	60,000 60,000				120	2,000,000		City engaged in a ground water management program with the Fresno I.D., Fresno Metropolitan F.C.D., and 15 County Water Works Districts.
FRESNO IRRIGATION DISTRICT	1921	241,300	210,000	164,000	Kings River	415,000	Friant-Kern Class 1 Class 2 Average	29,000 75,000 66,000	160,000	180	560-U	200	2,000,000	Not Avail.	District engaged in a ground water management program with the City of Fresno, Fresno Metropolitan F.C.D., and 15 County Water Works Districts. District allocated portion of City's Class 1 supply. Acreages include overlapping County Water Districts.
FRESNO METROPOLITAN FLOOD CONTROL DISTRICT	1956											Not Avail.			Special Act District. District engaged in a ground water management program with Fresno I.D., City of Fresno, and 15 County Water Works Districts. District owns and operates — 70 recharge basins.
JAMES IRRIGATION DISTRICT	1920	26,000	23,200	23,200			Delta-Mendota Canal Class 1 Sch. 2	35,300 9,700	38,000	2	120-U		1,352,000	$1,093,000	Long-term exchange contractor with U.S.B.R. District supplies 100% of farmers' needs. Subsurface conditions preclude artificial recharge.
KINGS RIVER CONSERVATION DISTRICT	1951	1,100,000		1,008,000											Special Act District providing for a public agency to represent the Kings River service area. District has developed a work plan for a ground water recharge study. Data included in listings for individual management entities within District boundaries.
LAGUNA IRRIGATION DISTRICT	1923	33,600	31,300	31,300	Kings River	60,000	Friant-Kern	(Surplus)	54,000	32	55-U	70	Not Avail.	177,000	Temporary contract with U.S.B.R. for surplus Friant-Kern Canal water.
LIBERTY MILL RACE COMPANY	Not Avail.	25,000	22,500	22,500	Kings River	15,000			56,000		20-U		Not Avail.	Not Avail.	
LIBERTY WATER DISTRICT	1970	21,200	19,000	18,700			Surplus CVP & Purch. Surplus Kings R.		54,000		16-U		Not Avail.	44,000	Short-term contract with U.S.B.R. for surplus Friant-Kern Canal water. Distribution canals owned by Liberty Canal Co., in which District owns stock.
RIVERDALE IRRIGATION DISTRICT	1923	15,000	14,000	14,000	Kings River	29,000	Friant-Kern Canal	(Surplus)	22,000		27-U		Not Avail.	Not Avail.	
SAN LUIS WATER DISTRICT	1951	56,700	54,000	51,000			San Luis Canal Delta-Mendota Canal	52,000 73,080	5,000	50	35-U		16,000,000	2,200,000	It is estimated that 4% of the District overlies usable ground water with respect to quality. Shallow ground water conditions exist in portions of the District.

(SEE SHEET 5 FOR NOTES)

TABLE A-1

SUMMARY OF STATISTICAL DATA FOR ENTITIES ENGAGED IN GROUND WATER MANAGEMENT IN THE SOUTHERN SAN JOAQUIN VALLEY

Management Entity	Date of Formation	Area in Acres			Local Surface Water		Imported Water		Estimated Gross Ground Water Extraction (Af/yr)	Project Facilities			Project Capital Investment	Annual Operating Budget	Comments
		Gross	Irrigable	Irrigated	Source	Amount (Af/yr)	Source	Amount (Af/yr)		Pipelines (Miles)	Canals (Miles)	Recharge Basins (Acres)			
FRESNO COUNTY															
STINSON CANAL COMPANY	Not Avail.	15,000	13,500	13,500	Kings River	18,000			27,000		12-U		Not Avail.	Not Avail.	Canal Co. includes the Stinson W.D. Subsurface conditions preclude artificial recharge.
STINSON WATER DISTRICT															Data included in listing for Stinson Canal Co.
TRACTION WATER DISTRICT	Not Avail.	2,600	2,600	2,600			Mendota Pool Class 1 Class 4	5,200 2,500	2,000	6	7-U		Not Avail.	Not Avail.	
WESTLANDS WATER DISTRICT	1952	603,200	544,100	530,000			San Luis Canal Mendota Pool	1,100,000 50,000	100,000	2000	6-U 9-L		$158,000,000	$20,400,000	Subsurface conditions preclude artificial recharge. Current long-term contract with U.S.B.R. for San Luis Canal water is for 900,000 AF (1,100,000 AF is under temporary agreement.)
KINGS COUNTY															
CORCORAN IRRIGATION DISTRICT	1919	48,000	42,800	42,800	Kings River Kaweah River	46,000 2,000			95,000	1	2-L 138-U	1,750	3,357,000	$632,000	
EMPIRE WEST SIDE IRRIGATION DISTRICT	1932	7,400	6,700	6,700	Kings River	10,000	State Water Project '79 Entitle. Max. Entitle.	3,000 3,000	5,000		14-U		Not Avail.	112,000	Subsurface conditions preclude artificial recharge.
JOHN HEINLEN MUTUAL WATER COMPANY	Not Avail.	13,000	11,700	11,700	Kings River	11,000			28,000				Not Avail.	Not Avail.	Company overlaps Lemoore Canal & Irrigation Co. Land owners with Lemore stock receive Lemoore water.
KINGS COUNTY WATER DISTRICT	1954	143,000	134,000	133,000	Kings River Kaweah River	122,000 18,000	Kings River Kaweah River Friant-Kern Canal	23,000	280,000		257-U	760	3,500,000	509,000	Contractor with U.S.B.R. for surplus Friant-Kern Canal water. District contracts for use of Ditch Co.-owned canal system. Acreages include Lakeside Irrigation W.D.
LAKESIDE IRRIGATION WATER DISTRICT	1962	31,800	29,000	28,500	Kaweah River	32,000	Surplus CVP, Kings River, and Exchanges Average	20,000	50,000		61-U		1,600,000	250,000	Short-term contract with U.S.B.R. for surplus Friant-Kern Canal water. District overlaps Kings County Water District with the exception of 373 Acres.
LEMOORE CANAL & IRRIGATION COMPANY	1904	60,000	53,000	53,000	Kings River	117,000			68,000		100-U		Not Avail.	Not Avail.	Lemoore includes Stratford I.D., Empire West Side I.D., and John Heinlen Mutual Water Co. Acreages include the aforementioned Districts and Co.
STRATFORD IRRIGATION DISTRICT	Not Avail.	10,500	9,400	9,400	Kings River	17,000			14,000				Not Avail.	Not Avail.	District overlaps Lemoore Canal & Irrigation Co. 7,000 AF (net) of Kings R. supply from stock in Canal Co. Subsurface conditions preclude artificial recharge.
TULARE LAKE BASIN WATER STORAGE DISTRICT	1926	192,400	180,000	180,000	Kings River	49,000	State Water Project '79 Entitle. Max Entitle.	62,600 110,000	110,000		10-L 23-U		2,700,000	2,700,000	Additional surface water available through private canal companies. Subsurface conditions preclude artificial recharge.
TULARE COUNTY															
ALPAUGH IRRIGATION DISTRICT	1915	8,400	7,900	7,900			Friant-Kern Canal Surplus CVC Max.	3,400 1,000	19,000		75-U	10	Not Avail.	310,000	Short-term contract with U.S.B.R. for surplus Friant-Kern Canal water. Short-term Cross Valley Canal contract. Subsurface conditions preclude artificial recharge.

(SEE SHEET 5 FOR NOTES)

TABLE A-1

SUMMARY OF STATISTICAL DATA FOR ENTITIES ENGAGED IN GROUND WATER MANAGEMENT IN THE SOUTHERN SAN JOAQUIN VALLEY

Management Entity	Date of Formation	Area in Acres			Local Surface Water		Imported Water		Estimated Gross Ground Water Extraction (Af/yr)	Project Facilities			Project Capital Investment	Annual Operating Budget	Comments
		Gross	Irrigable	Irrigated	Source	Amount (Af/yr)	Source	Amount (Af/yr)		Pipelines (Miles)	Canals (Miles)	Recharge Basins (Acres)			
TULARE COUNTY															
ALTA IRRIGATION DISTRICT	1882	129,400	118,000	113,000	Kings River	159,000	Friant-Kern Canal	(Surplus)	230,000		300-U	75	$4,500,000	$900,000	Short-term contract with U.S.B.R. for surplus Friant-Kern Canal water. (Have not taken water yet.)
DELANO-EARLIMART IRRIGATION DISTRICT	1938	55,700	49,700	49,700			Friant-Kern Canal Class 1 Class 2 (Max.) Avg. Total	 108,800 74,500 146,050	18,000	170		5	10,000,000	1,000,000	
EXETER IRRIGATION DISTRICT	1937	14,500	11,500	11,500			Friant-Kern Canal Class 1 Class 2 (Max.) Avg. Total	 11,500 19,000 21,000	14,000	67			3,250,000	225,000	Subsurface conditions preclude artificial recharge with the exception of limited capacity in a dry creek channel.
HILLS VALLEY IRRIGATION DISTRICT	1952	4,500	2,000	1,100			Cross Valley Canal (Max.)	2,000	1,000	10			Not Avail.	Not Avail.	Arvin-Edison W.S.D.-Cross Valley Canal exchangor. Subsurface conditions preclude artificial recharge.
IVANHOE IRRIGATION DISTRICT	1948	11,000	9,800	9,800	Kaweah River	2,800	Friant-Kern Canal Class 1 Class 2 (Max.) Average	 7,700 7,900 11,650	15,000	46		13	2,150,000	250,000	
KAWEAH DELTA WATER CONSERVATION DISTRICT	1927	337,000	305,000	270,000	Kaweah River	400,000	Friant-Kern Canal (Surplus)	24,000	130,000		600-U	5,000	4,200,000	Not Avail.	Ground water extraction by public districts and mutual water companies within the District. Data included under listings for management entities within the District.
KERN-TULARE WATER DISTRICT	1974	30,700		19,200	Kern River	20,000	Cross Valley Canal	41,000	33,000	5			7,000,000	Not Avail.	Kern River water through contract with the City of Bakersfield. Distribution system delivery capability is 25,000 AF.
LINDMORE IRRIGATION DISTRICT	1937	27,200	26,400	24,000			Friant-Kern Canal Class 1 Class 2 (Max.) Avg. Total	 33,000 22,000 44,000	28,000	123			5,000,000	780,000	Subsurface conditions preclude artificial recharge.
LOWER TULE RIVER IRRIGATION DISTRICT	1950	103,100	93,200	84,000	Tule River	52,600	Friant-Kern Class 1 Class 2 (Max.) Avg. Total Cross Valley	 61,200 238,000 180,200 31,000			170-U	300	1,712,000	Not Avail.	Arvin-Edison W.S.D.-Cross Valley Canal exchangor.
ORANGE COVE IRRIGATION DISTRICT	1937	28,000	26,000	23,000			Friant-Kern Canal Class 1 Average	 39,200 39,200	30,000	300	1		3,500,000	500,000	Subsurface conditions preclude artificial recharge.
PIONEER WATER COMPANY	1888	4,000	3,400	3,000	Tule River	7,000			3,000	12		Not Avail.	1,200,000	57,000	
PIXLEY IRRIGATION DISTRICT	1958	69,600	64,000	50,000			Friant-Kern (Surplus) Cross Valley Canal	1,700 31,000	130,000		40-U	26	1,180,000	Not Avail.	Temporary contract with U.S.B.R. for surplus Friant-Kern Canal water. Arvin-Edison W.S.D.-Cross Valley Canal exchangor.
PORTERVILLE IRRIGATION DISTRICT	1949	16,900	14,000	13,600	Tule River	6,000	Friant-Kern Canal Class 1 Class 2 Average	 16,000 30,000 31,000	15,000	3	17-U	5	Not Avail.	250,000	Distribution canals owned by 3 ditch companies and used by District through contract.
RAG GULCH WATER DISTRICT	1955	6,000	5,700	5,000	Kern River	3,000	Friant-Kern Surplus Average Cross Valley Canal	3,700 13,300		22			2,100,000	Not Avail.	Kern River water through contract with City of Bakersfield. Arvin-Edison W.S.D.-Cross Valley Canal exchangor. Short-term contract with U.S.B.R. for surplus Friant-Kern Canal water.
SAUCELITO IRRIGATION DISTRICT	1941	19,200	17,600	17,600	Tule River	Minor	Friant-Kern Canal Class 1 Class 2 Average	 21,200 32,800 37,600	15,000	53		2	3,772,000	1,628,000	Deer Creek Channel used for ground water recharge.

(SEE SHEET 5 FOR NOTES)

TABLE A-1

SUMMARY OF STATISTICAL DATA FOR ENTITIES ENGAGED IN GROUND WATER MANAGEMENT IN THE SOUTHERN SAN JOAQUIN VALLEY

Management Entity	Date of Formation	Area in Acres			Local Surface Water		Imported Water		Estimated Gross Ground Water Extraction (Af/yr)	Project Facilities			Project Capital Investment	Annual Operating Budget	Comments
		Gross	Irrigable	Irrigated	Source	Amount (Af/yr)	Source	Amount (Af/yr)		Pipelines (Miles)	Canals (Miles)	Recharge Basins (Acres)			
TULARE COUNTY															
STONE CORRAL IRRIGATION DISTRICT	1948	6,600	6,400	5,100			Friant-Kern Canal Class 1 Average	10,000 10,000	5,000	30			$1,500,000	$180,000	Subsurface conditions preclude artificial recharge.
TERRA BELLA IRRIGATION DISTRICT	1915	14,000	13,300	10,300			Friant-Kern Canal Class 1 Average	29,000 29,000	2,000	155		20	6,073,000	792,000	Water diverted from Deer Creek and ponded for recharge.
TULARE IRRIGATION DISTRICT	1889	75,000	68,600	57,800	Kaweah River	55,000	Friant-Kern Canal Class 1 Class 2 (Max.) Average	30,000 141,000 100,500	65,000	25	275-U	1,100	220,000	800,000	Recharge basins within District are operated for, or owned jointly with, Kaweah Delta Water Conservation District.
KERN COUNTY															
ARVIN-EDISON WATER STORAGE DISTRICT	1942	131,700	125,700	104,800			Friant-Kern Canal Class 1 Class 2 Average	40,000 313,000 196,500	120,000	170	44-L	900	46,000,000	5,000,000	Cross Valley Canal exchange program with Districts in Fresno & Tulare Counties.
BAKERSFIELD, CITY OF WATER DEPARTMENT	1976				Kern River	123,000						2,760	17,500,000	Not Avail.	Ground water recharge and recovery program being formulated with local management entities utilizing the City's 2,760 acre recharge area. Executed long-term contracts for the sale of Kern River water to local districts.
BUENA VISTA WATER STORAGE DISTRICT	1924	50,000	42,000	41,000	Kern River	120,000	State Water Project '79 Entitle. Max. Entitle. Friant-Kern	17,900 25,000 (Surplus)	50,000	10	6-L 110-U		4,000,000	650,000	Figures do not include overlap with Henry Miller W.D. Contract with U.S.B.R. for surplus Friant-Kern Canal water. Contractual arrangements for State water effected through the Kern County Water Agency.
CAWELO WATER DISTRICT	1965	44,800	40,000	38,000	Kern River	27,000	State Water Project '79 Entitle. Max. Entitle.	32,200 45,000	55,000	32	7-L		26,000,000	4,860,000	Kern River water purchased through a long-term contract with City of Bakersfield. Contractual arrangements for State water were effected through the Kern County Water Agency.
HENRY MILLER WATER DISTRICT	1964	25,400	22,400	22,400	Kern River	4,000	State Water Project '79 Entitle. Max. Entitle.	29,900 41,800	33,000		50-U		1,400,000	800,000	District encompasses the Buena Vista Lake bottom which is not conducive to artificial recharge. Contractual arrangements for State water were effected through the Kern County Water Agency.
KERN COUNTY WATER AGENCY	1961						State Water Project '79 Entitle. Max. Entitle.	583,900 1,153,400							Agency is the coordinating fiscal agent for those Kern County entities receiving water from the State Water Project. Data tabulated for individual Kern County management entities.
KERN COUNTY WATER AGENCY IMPROVEMENT DISTRICT NO. 4	1971	65,400		18,000			State Water Project '79 Entitle. Max. Entitle.	45,400 77,000		10			22,800,000	3,000,000	Includes the City of Bakersfield and certain adjacent areas.
KERN DELTA WATER DISTRICT	1965	125,000	118,000	118,000	Kern River	150,000	State Water Project '79 Entitle. Max. Entitle.	21,500 30,000	230,000		136-U		4,500,000	Not Avail.	Contractual arrangements for State water were effected through the Kern County Water Agency.
NORTH KERN WATER STORAGE DISTRICT	1935	97,400	87,300	80,600	Kern River	175,000			148,000	20	182-U 25-L	1,500	9,813,000	2,600,000	District includes the James-Pioneer Improvement District.
OLCESE WATER DISTRICT	1968	8,800	2,200	1,200	Kern River	4,000				4			2,000,000	80,000	Ground water recharge and recovery program being formulated with the City of Bakersfield.
ROSEDALE-RIO BRAVO WATER STORAGE DISTRICT	1959	41,000	35,700	35,700	Kern River	40,000	Friant-Kern State Water Project '79 Entitle. Max. Entitle.	(Surplus) 24,400 35,000	110,000		1-U	300	400,000	173,000	Short-term contractor with U.S.B.R. for surplus Friant-Kern Canal water. Contractual arrangements for State water were effected through the Kern County Water Agency.

(SEE SHEET 5 FOR NOTES)

TABLE A-1

SUMMARY OF STATISTICAL DATA FOR ENTITIES ENGAGED IN GROUND WATER MANAGEMENT IN THE SOUTHERN SAN JOAQUIN VALLEY

Management Entity	Date of Formation	Area in Acres			Local Surface Water		Imported Water		Estimated Gross Ground Water Extraction (Af/yr)	Project Facilities			Project Capital Investment	Annual Operating Budget	Comments
		Gross	Irrigable	Irrigated	Source	Amount (Af/yr)	Source	Amount (Af/yr)		Pipelines (Miles)	Canals (Miles)	Recharge Basins (Acres)			
KERN COUNTY															
SEMITROPIC WATER STORAGE DISTRICT	1958	224,000	120,000	120,000			Friant-Kern State Water Project '79 Entitle. Max. Entitle.	(Surplus) 109,700 183,100	250,000	135	42-U		$31,000,000	$5,000,000	District includes the Buttonwillow and Pond-Poso Improvement Districts. Plan being formulated for direct artificial recharge in absorptive areas. Contractual arrangements for State water were effected through the Kern County Water Agency.
SHAFTER-WASCO IRRIGATION DISTRICT	1937	37,800	32,000	30,800			Friant-Kern Class 1 (Max.) Class 2 (Max.) Average	50,000 39,600 69,800	23,000	120	1-U		8,500,000	240,000	Subsurface conditions preclude artificial recharge.
SOUTHERN SAN JOAQUIN MUNICIPAL UTILITY DISTRICT	1935	60,700	46,000	46,000			Friant-Kern Class 1 (Max.) Class 2 (Max.) Average	97,000 50,000 122,000	16,000	160			Not Avail.	Not Avail.	Subsurface conditions preclude artificial recharge.
WEST KERN COUNTY WATER DISTRICT	1959	163,200		(Minor)	Kern River	(Surplus)	State Water Project '79 Entitle. Max. Entitle.	16,800 25,000	12,000	75			10,000,000	4,400,000	M & I District with (M & I) Contract for State water through the Kern County Water Agency. Surface water is recharged in Kern River Channel, and subsequently recovered, through District wells.
WHEELER RIDGE-MARICOPA WATER STORAGE DISTRICT	1959	145,000	132,000	100,000			State Water Project '79 Entitle. Max. Entitle.	216,900 302,900	83,000	300	7-L		48,000,000	12,300,000	Program under study for District recharge and recovery. Contractual arrangements for State water were effected through the Kern County Water Agency.

NOTES:

1. Management entities are tabulated within the County in which the majority of the bounded lands are found.

2. Those entities that do not rely upon the extraction of ground water, or whose reliance has been reduced to a minor amount (not included in tabulation), are listed below:

Broadview W.D.	Mercy Springs W.D.
Central California I.D.	Oro Loma W.D.
Columbia Canal Co.	Panoche W.D.
Eagle Field W.D.	Tea Pot Dome I.D.
Firebaugh Canal Co.	Tranquillity I.D.
Kings River W.D.	Widren W.D.
Lindsay-Strathmore I.D.	

3. Those entities whose water supply is developed solely from the extraction of ground water (not included in the tabulation), and exist with the institutional framework necessary to effect the contractual arrangements for a supplemental water supply if and when available, are listed below:

Ducor I.D.	Progressive W.D.
Farmers W.D.	Raisin City W.D.
Gravelly Ford W.D.	Sierra W.D.
Hope W.D.	

4. Entries are not additive with respect to acreage and water supply where there is overlap between a given entity and one or more other entities.

5. *Local Surface Water* entries are taken to be long-term average annual amounts.

6. *Imported Water* does not reflect purchases made on a year to year basis where those purchases are not effected within the framework of a contract.

7. Average project allocations from the Friant-Kern Canal are taken to be the sum of the Class 1 contractual maximum and 50 percent of the Class 2 contractual maximum.

8. *Estimated Gross Ground Water Extraction* is defined as that average annual quantity of water required to be extracted from the underground to meet the applied water requirement. In the absence of available data, estimates are based on the following assumptions:
   (a) Applied water requirement is equal to 3.0 acre-feet per irrigated acre.
   (b) Entities with a supply from the Friant-Kern Canal receive the indicated average project allocation.
   (c) Entities with a supply from the State Water Project receive their 1979 entitlement.
   (d) All surface water supplies are delivered to the satisfaction of the applied water requirement depleted by conveyance losses.

9. Canals are listed as lined (L) and unlined (U).

10. Sources:
    (a) Staff of, and or consultants for, all management entities.
    (b) Twenty-Seventh Annual Water Supply Report — 1977, United States Department of the Interior, Bureau of Reclamation, Mid-Pacific Region.
    (c) The California State Water Project — 1977, Activities and Future Management Plans, Bulletin 132-78, State of California, Department of Water Resources (October 1978).
    (d) Water Supply Report 1977, Kern County Water Agency (May 1978).
    (e) Boundaries of Public Water Agencies, San Joaquin Valley, State of California, Department of Water Resources, San Joaquin District (July 1978).

TABLE A-2
SUMMARY OF CHARACTERISTICS OF GROUND WATER MANAGEMENT PROGRAMS IN THE SOUTHERN SAN JOAQUIN VALLEY

Management Entity	Surface Water Supply Source			Ground Water Recharge Methods					Ground Water Extraction Facilities		Ground Water Management Program	Hydrologic Inventory and Ground Water Monitoring Program	Exchange Programs	Comments
	Local Surface	Imported		Surface Delivery in Lieu of Pumping	Basins/ Ponds	Natural Channels	Unlined Canals	Off Season Irrigation	Mgt. Entity	Private				
		State	Federal											
MADERA COUNTY														
CHOWCHILLA WATER DISTRICT			●	●	●	●	●	●		●	●	●	●	16% of Class 2 amount assigned to La Branza W.D.
MADERA IRRIGATION DISTRICT	●		●	●	●	●	●			●	●	●		Has contract with U.S.G.S. for the development of a digital ground water model.
FRESNO COUNTY														
CONSOLIDATED IRRIGATION DISTRICT	●		●	●	●	●	●			●	●	●	●	Short-term contract with U.S.B.R. for surplus Friant-Kern Canal water. District owns or has easements for 1500 Acres of recharge basins.
CRESCENT CANAL COMPANY	●			●					●	●	●		●	Subsurface conditions preclude artificial recharge.
FRESNO, CITY OF			●		●	●					●		●	City engaged in a ground water management program with the Fresno I.D., Fresno Metropolitan F.C.D., and 15 County Water Works Districts.
FRESNO IRRIGATION DISTRICT	●		●	●	●	●	●			●	●	●	●	District engaged in a ground water management program with the City of Fresno, Fresno Metropolitan F.C.D., and 15 County Water Works Districts. District allocated portion of City's Class 1 supply. Acreages include overlapping County Water Districts.
FRESNO MUNICIPAL FLOOD CONTROL DISTRICT					●						●			Special Act District. District engaged in a ground water management program with Fresno I.D., City of Fresno, and 15 County Water Works Districts. District owns and operates —70 recharge basins.
JAMES IRRIGATION DISTRICT			●	●					●		●	●	●	Long-term exchange contractor with U.S.B.R. District supplies 100% of farmers' needs. Subsurface conditions preclude artificial recharge.
KINGS RIVER CONSERVATION DISTRICT														Special Act District providing for a public agency to represent the Kings River service area. District has developed a work plan for ground water recharge study. Data included in listings for individual management entities within District boundaries.
LAGUNA IRRIGATION DISTRICT	●		●	●	●		●	●	●	●	●			Temporary contract with U.S.B.R. for surplus Friant-Kern Canal water.
LIBERTY MILL RACE COMPANY	●			●		●	●	●		●	●		●	
LIBERTY WATER DISTRICT	●		●	●		●	●	●		●	●		●	Short-term contract with U.S.B.R. for surplus Friant-Kern Canal water. Distribution canals owned by Liberty Canal Co., in which District owns stock.
RIVERDALE IRRIGATION DISTRICT	●		●	●		●	●	●		●	●		●	
SAN LUIS WATER DISTRICT			●	●						●	●	●	●	It is estimated that 4% of the District overlies usable ground water with respect to quality. Shallow ground water conditions exist in portions of the District.

(SEE SHEET 5 FOR NOTES)

TABLE A-2

SUMMARY OF CHARACTERISTICS OF GROUND WATER MANAGEMENT PROGRAMS IN THE SOUTHERN SAN JOAQUIN VALLEY

Management Entity	Surface Water Supply Source: Local Surface	Surface Water Supply Source: Imported: State	Surface Water Supply Source: Imported: Federal	Ground Water Recharge Methods: Surface Delivery in Lieu of Pumping	Ground Water Recharge Methods: Basins/ Ponds	Ground Water Recharge Methods: Natural Channels	Ground Water Recharge Methods: Unlined Canals	Ground Water Recharge Methods: Off Season Irrigation	Ground Water Extraction Facilities: Mgt. Entity	Ground Water Extraction Facilities: Private	Ground Water Management Program	Hydrologic Inventory and Ground Water Monitoring Program	Exchange Programs	Comments
FRESNO COUNTY														
STINSON CANAL COMPANY	●			●						●	●		●	Canal Co. includes the Stinson W.D. Subsurface conditions preclude artificial recharge.
STINSON WATER DISTRICT														Data included in listing for Stinson Canal Co.
TRACTION WATER DISTRICT	●		●	●					●	●	●	●		
WESTLANDS WATER DISTRICT			●	●						●	●	●		Subsurface conditions preclude artificial recharge. Current long-term contract with U.S.B.R. for San Luis Canal water is for 900,000 AF (1,100,000 AF is under temporary agreement).
KINGS COUNTY														
CORCORAN IRRIGATION DISTRICT	●			●	●		●	●	●	●	●	●		
EMPIRE WEST SIDE IRRIGATION DISTRICT	●	●		●						●	●		●	Subsurface conditions preclude artificial recharge.
JOHN HEINLEN MUTUAL WATER COMPANY	●			●		●	●	●		●	●			Company overlaps Lemoore Canal & Irrigation Co. Land owners with Lemoore stock receive Lemoore water.
KINGS COUNTY WATER DISTRICT	●		●	●	●	●	●	●		●	●	●	●	Contractor with U.S.B.R. for surplus Friant-Kern Canal water. District contracts for use of Ditch Co.-owned canal system. Acreages include Lakeside Irrigation W.D.
LAKESIDE IRRIGATION WATER DISTRICT	●		●	●	●	●	●	●		●	●	●	●	Short-term contract with U.S.B.R. for surplus Friant-Kern Canal water. District overlaps Kings County Water District with the exception of 373 Acres.
LEMOORE CANAL & IRRIGATION COMPANY	●			●		●	●	●		●	●	●	●	Lemoore includes Stratford I.D., Empire West Side I.D., and John Heinlen Mutual Water Co. Acreages include the aforementioned Districts and Co.
STRATFORD IRRIGATION DISTRICT	●			●						●	●		●	District overlaps Lemoore Canal & Irrigation Co. 7000 AF (net) of Kings R. supply from stock in Canal Co. Subsurface conditions preclude artificial recharge.
TULARE LAKE BASIN WATER STORAGE DISTRICT	●	●		●						●	●		●	Additional surface water available through private canal companies. Subsurface conditions preclude artificial recharge.
TULARE COUNTY														
ALPAUGH IRRIGATION DISTRICT			●	●					●	●	●	●	●	Short-term contract with U.S.B.R. for surplus Friant-Kern Canal water. Short-term Cross Valley Canal contract. Subsurface conditions preclude artificial recharge.

(SEE SHEET 5 FOR NOTES)

TABLE A-2

SUMMARY OF CHARACTERISTICS OF GROUND WATER MANAGEMENT PROGRAMS IN THE SOUTHERN SAN JOAQUIN VALLEY

Management Entity	Surface Water Supply Source			Ground Water Recharge Methods					Ground Water Extraction Facilities		Ground Water Management Program	Hydrologic Inventory and Ground Water Monitoring Program	Exchange Programs	Comments
	Local Surface	Imported												
		State	Federal	Surface Delivery in Lieu of Pumping	Basins/ Ponds	Natural Channels	Unlined Canals	Off Season Irrigation	Mgt. Entity	Private				
TULARE COUNTY														
ALTA IRRIGATION DISTRICT	●			●	●	●	●	●		●	●	●	●	Short-term contract with U.S.B.R. for surplus Friant-Kern Canal water. (Have not taken water yet.)
DELANO-EARLIMART IRRIGATION DISTRICT			●	●	●	●		●		●	●	●	●	
EXETER IRRIGATION DISTRICT			●	●		●				●	●	●		Subsurface conditions preclude artificial recharge with the exception of limited capacity in a dry creek channel.
HILLS VALLEY IRRIGATION DISTRICT			●	●						●	●		●	Arvin-Edison W.S.D.-Cross Valley Canal exchangor. Subsurface conditions preclude artificial recharge.
IVANHOE IRRIGATION DISTRICT	●		●	●	●	●				●	●	●	●	
KAWEAH DELTA WATER CONSERVATION DISTRICT	●		●	●	●	●	●			●	●	●	●	Ground water extraction by public districts and mutual water companies within the District. Data included under listings for management entities within the District.
KERN-TULARE WATER DISTRICT	●		●	●						●	●		●	Kern River water through contract with the City of Bakersfield. Distribution system delivery capability is 25,000 AF.
LINDMORE IRRIGATION DISTRICT			●	●						●	●	●		Subsurface conditions preclude artificial recharge.
LOWER TULE RIVER IRRIGATION DISTRICT	●		●	●	●	●	●	●		●	●	●	●	Arvin-Edison W.S.D.-Cross Valley Canal exchangor.
ORANGE COVE IRRIGATION DISTRICT			●	●				●		●	●	●	●	Subsurface conditions preclude artificial recharge.
PIONEER WATER COMPANY	●			●	●	●			●	●	●	●	●	
PIXLEY IRRIGATION DISTRICT			●	●		●	●	●		●	●	●	●	Temporary contract with U.S.B.R. for surplus Friant-Kern Canal water. Arvin-Edison W.S.D.-Cross Valley Canal exchangor.
PORTERVILLE IRRIGATION DISTRICT	●		●	●	●	●	●	●		●	●	●	●	Distribution canals owned by 3 ditch companies and used by District through contract.
RAG GULCH WATER DISTRICT	●		●	●						●	●		●	Kern River water through contract with City of Bakersfield. Arvin-Edison W.S.D.-Cross Valley Canal exchangor. Short-term contract with U.S.B.R. for surplus Friant-Kern Canal water.
SAUCELITO IRRIGATION DISTRICT			●	●	●	●				●	●	●	●	Deer Creek Channel used for ground water recharge.

(SEE SHEET 5 FOR NOTES)

TABLE A-2
SUMMARY OF CHARACTERISTICS OF GROUND WATER MANAGEMENT PROGRAMS IN THE SOUTHERN SAN JOAQUIN VALLEY

Management Entity	Surface Water Supply Source			Ground Water Recharge Methods					Ground Water Extraction Facilities		Ground Water Management Program	Hydrologic Inventory and Ground Water Monitoring Program	Exchange Programs	Comments
	Local Surface	Imported		Surface Delivery in Lieu of Pumping	Basins/ Ponds	Natural Channels	Unlined Canals	Off Season Irrigation	Mgt. Entity	Private				
		State	Federal											
TULARE COUNTY														
STONE CORRAL IRRIGATION DISTRICT			●	●						●	●	●		Subsurface conditions preclude artificial recharge.
TERRA BELLA IRRIGATION DISTRICT			●	●	●	●			●		●	●	●	Water diverted from Deer Creek and ponded for recharge.
TULARE IRRIGATION DISTRICT	●		●	●	●	●	●	●		●	●	●	●	Recharge basins within District are operated for, or owned jointly with, Kaweah Delta Water Conservation District.
KERN COUNTY														
ARVIN-EDISON WATER STORAGE DISTRICT			●	●	●				●	●	●	●	●	Cross Valley Canal exchange program with Districts in Fresno & Tulare Counties.
BAKERSFIELD, CITY OF	●					●				●	●		●	Ground water recharge and recovery program being formulated with local management entities utilizing the City's 2,760 acre recharge area. Executed long-term contracts for the sale of Kern River water to local districts.
BUENA VISTA WATER STORAGE DISTRICT	●	●	●	●		●	●			●	●	●	●	Figures do not include overlap with Henry Miller W.D. Contract with U.S.B.R. for surplus Friant-Kern Canal water. Contractual arrangements for State water effected through the Kern County Water Agency.
CAWELO WATER DISTRICT	●	●		●		●		●		●	●	●	●	Kern River water purchased through a long-term contract with City of Bakersfield. Contractual arrangements for State water were effected through the Kern County Water Agency.
HENRY MILLER WATER DISTRICT	●	●		●					●		●	●	●	District encompasses the Buena Vista Lake bottom which is not conducive to artificial recharge. Contractual arrangements for State water were effected through the Kern County Water Agency.
KERN COUNTY WATER AGENCY		●		●		●				●	●	●	●	Agency is the coordinating fiscal agent for those Kern County entities receiving water from the State Water Project. Data tabulated for individual Kern County management entities.
KERN COUNTY WATER AGENCY IMPROVEMENT DISTRICT NO. 4		●		●		●	●			●	●	●	●	Includes the City of Bakersfield and certain adjacent areas.
KERN DELTA WATER DISTRICT	●	●		●			●			●	●		●	Contractual arrangements for State water were effected through the Kern County Water Agency.
NORTH KERN WATER STORAGE DISTRICT	●			●	●	●	●	●	●	●	●	●	●	District includes the James-Pioneer Improvement District.
OLCESE WATER DISTRICT	●					●			●	●	●		●	Ground water recharge and recovery program being formulated with the City of Bakersfield.
ROSEDALE-RIO BRAVO WATER STORAGE DISTRICT	●	●	●	●	●	●				●	●	●	●	Short-term contractor with U.S.B.R. for surplus Friant-Kern Canal water. Contractual arrangements for State water were effected through the Kern County Water Agency.

(SEE SHEET 5 FOR NOTES)

TABLE A-2
SUMMARY OF CHARACTERISTICS OF GROUND WATER MANAGEMENT PROGRAMS IN THE SOUTHERN SAN JOAQUIN VALLEY

Management Entity	Surface Water Supply Source			Ground Water Recharge Methods					Ground Water Extraction Facilities		Ground Water Management Program	Hydrologic Inventory and Ground Water Monitoring Program	Exchange Programs	Comments
	Local Surface	Imported: State	Imported: Federal	Surface Delivery in Lieu of Pumping	Basins/ Ponds	Natural Channels	Unlined Canals	Off Season Irrigation	Mgt. Entity	Private				
KERN COUNTY														
SEMITROPIC WATER STORAGE DISTRICT		●		●				●		●	●	●	●	District includes the Buttonwillow and Pond-Poso Improvement Districts. Plan being formulated for direct artificial recharge in absorptive areas. Contractual arrangements for State water were effected through the Kern County Water Agency.
SHAFTER-WASCO IRRIGATION DISTRICT			●	●						●	●	●	●	Subsurface conditions preclude artificial recharge.
SOUTHERN SAN JOAQUIN MUNICIPAL UTILITY DISTRICT			●	●				●		●	●	●	●	Subsurface conditions preclude artificial recharge.
WEST KERN COUNTY WATER DISTRICT	●	●	●			●			●		●	●	●	M & I District with (M & I) Contract for State water through the Kern County Water Agency. Surface water is recharged in Kern River Channel, and subsequently recovered, through District wells.
WHEELER RIDGE-MARICOPA WATER STORAGE DISTRICT		●		●						●	●	●	●	Program under study for District recharge and recovery. Contractual arrangements for State water were effected through the Kern County Water Agency.

NOTES:

1. Management entities are tabulated within the County in which the majority of the bounded lands are found.

2. Those entities that do not rely upon the extraction of ground water, or whose reliance has been reduced to a minor amount (not included in tabulation), are listed below:

Broadview W.D.	Mercy Springs W.D.
Central California I.D.	Oro Loma W.D.
Columbia Canal Co.	Panoche W.D.
Eagle Field W.D.	Tea Pot Dome I.D.
Firebaugh Canal Co.	Tranquillity I.D.
Kings River W.D.	Widren W.D.
Lindsay-Strathmore I.D.	

3. Those entities whose water supply is developed solely from the extraction of ground water (not included in the tabulation), and exist with the institutional framework necessary to effect the contractual arrangements for a supplemental water supply if and when available, are listed below:

Ducor I.D.	Progressive W.D.
Farmers W.D.	Raisin City W.D.
Gravelly Ford W.D.	Sierra W.D.
Hope W.D.	

4. Ground water recharge in *Natural Channels*, as used herein, includes that water which is intentionally spread in natural channels for the purpose of ground water replenishment as opposed to that which occurs naturally.

5. *Off-Season Irrigation* involves the application of water to the land for the purpose of ground water replenishment during years in which the available water supply exceeds irrigation requirements.